PRIVATE
DEPOSITORY

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LIV. No. 6. APRIL 1894.

INVITATION OF LADIES TO THE ORDINARY MEETINGS OF THE SOCIETY.

The attention of Fellows is called to the fact that ladies are only admitted at the Evening Meetings of the Society by special invitation of the President, sanctioned by the Council. The invitations are issued at the commencement of each Session.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LIV. APRIL 13, 1894. No. 6

E. B. KNOBEL, Esq., Vice-President, in the Chair.

Lyndon Bolton, B.A., Patent Office, Chancery Lane, W.C.;
F. W. Dyson, M.A., Royal Observatory, Greenwich, S.E.;
G. P. Jenkins, Esq., Llangefni, Anglesea, North Wales;
W. Redfern Kelly, Mem. Inst. C.E., Dalriada, Malone Park, Belfast;

were balloted for and duly elected Fellows of the Society.

The following were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

The Rev. Thomas Windmill Claridge, M.A., Tamworth, Staffordshire (proposed by Rev. Thomas Jones);
David Goudie Simpson, 199 Camberwell Grove, Denmark Hill, S.E. (proposed by Gainsford Bruce);
Rev. Ernest Harrison Smith, M.A., R.N., Chaplain and Naval Instructor H.M.S. "Tourmaline," North American and West Indian Station (proposed by Bertram Bennett);
Sir John Benjamin Stone, K.B., The Grange, Erdington, near Birmingham (proposed by W. Shackleton).

Seventy-one presents were announced as having been received since the last meeting of the Society, including, amongst others—

Kiel Observatory publications, no. ix. (E. Lamp, Comet 1891, I.; H. Kreutz, Comet 1873, V., &c.), presented by the Observatory. L. S. Fabry, Étude sur la probabilité des comètes hyperboliques et l'Origine des Comètes, presented by the author; Barlow and Bryan, Elementary Mathematical Astronomy, third edition; and Briggs and Bryan, Co-ordinate Geometry, part 1, presented by the editor.

Remarks on the Best Methods of Determining the Positions of the Planets by Observation. By David Gill, LL.D., F.R.S., Her Majesty's Astronomer at the Cape of Good Hope.

In the *Astronomical Journal*, No. 311 (1894 February 10), Professor Simon Newcomb has called attention to the great accuracy attainable in heliometer measures of the distance and position-angle of planets from selected comparison stars, and of the precision in the resulting places of the planet which may be reached when the comparison stars have been observed on the meridian at many different observatories, and specially when these stars have also been connected by triangulation.

The instance quoted by Professor Newcomb is afforded by the heliometer observations of *Mars* at Ascension in 1877, by which a then unexplained apparent periodic inequality in the motion of *Mars* was detected. This apparent inequality has since been shown to have arisen from an inadvertent error in the computation of the nutation in the special ephemeris of *Mars* supplied by the *Nautical Almanac* office.

Thus, to use Professor Newcomb's words, "a minute inequality, which would never have been noticed in even the best meridian observations, was brought to light, and mapped in a diagram so as to be unmistakable."

Striking as this result may be, the accuracy of the *Mars* observations is very inferior to that realised in the observations of the minor planet *Victoria* in 1889; and, pending the publication of the complete work now in the press, it may not be out of place to give the following illustrations.

It should be mentioned that the exactness of the observations has been the chief cause in the delay of publication. The results of their preliminary discussion (orally communicated to the Society at its meeting on 1893 March 10) showed, on closer examination, that the accuracy of the existing Solar Tables and the employment of seven-figure logarithms in the computation of the ephemeris from the elements were insufficient to respond to the accuracy of the observations.

With great kindness Professor Tietjen undertook the labour of computing a new ephemeris, with special perturbations and the use of eight-figure logarithms, at the office of the *Berliner Jahrbuch*. This has also involved a complete re-computation of the whole work, and the introduction of many refinements hardly applicable in the first discussion. The observations are now represented by residuals less by one-half than those previously found. This latter remark, of course, applies chiefly to the absolute errors of the planet in right ascension and declination, and not to the separate values of the parallax, because in the latter case the comparative roughness of the original ephemeris is to a great extent eliminated by the nearly simultaneous epochs of the observations in opposite hemispheres from which the parallax is deduced.

A "Set" of observations is defined as all the observations of the same class made by the same observer at the same sitting.

The various sets of observations are combined in "Groups," following each other in the order of date. The limits of these groups are so fixed as to afford in general a strong determination of the planet's right ascension, declination, and parallax from each group, the only exception to this rule being Group I., because the only observations before June 15 were a single set at the Cape on June 10, and a single set at Göttingen on June 11, both consisting only of measures of distance of the planet from the opposite stars κ and μ; and it seemed undesirable to unduly extend the limits of Group II. to include these comparatively isolated observations. Group I. thus contains only two sets of observations, and these afford a determination of the parallax, but no data to distinguish between the tabular errors in right ascension and declination.

The observations of each group are reduced to a common epoch; and in the following table are given the actual corrections, $\Delta\alpha \cos\delta$ and $\Delta\delta$, applicable to the new ephemeris, which result directly from the observations.

Group.	Period covered by the observations.	Epoch to which each group is reduced.	$\Delta\alpha \cos\delta$ O−C arc.	Weight.	$\Delta\delta$ O−C	Weight.	No. of sets.	No. of stars.	Tabular effect of Lunar perturbation. $\Delta\alpha \cos\delta$	Tabular effect of Lunar perturbation. $\Delta\delta$
			″		″					″
II.	June 15–18	June 17·0	−0·139	11·6	+0·686	12·7	12	2	+2·49	−1·22
III.	19–25	22·0	− ·153	17·8	+ ·683	19·5	22	2	+7·28	+0·74
IV.	June 26 July 2	29·0	− ·207	13·5	+ ·755	35·1	24	10	+0·98	+2·20
V.	July 3–8	July 6·0	− ·162	13·7	+ ·743	16·0	11	7	−7·33	−0·37
VI.	9–12	11·0	− ·237	12·7	+ ·746	13·9	14	3	−3·10	−2·17
VII.	15–19	18·0	− ·228	22·8	+ ·791	22·7	10	3	+7·49	+0·04
VIII.	20–22	21·5	− ·173	19·6	+ ·808	11·8	7	1	+6·93	+1·76
IX.	23–24	24·0	− ·235	20·4	+ ·873	25·1	14	4	+3·98	+2·45
X.	25–27	26·0	− ·257	17·4	+ ·832	14·3	4	1	+0·76	+2·52
XI.	July 28 Aug. 2	Aug. 1·0	− ·343	42·2	+ ·821	38·6	31	8	−1·12	+0·36
XII.	Aug. 4–9	7·0	− ·442	22·4	+ ·746	21·4	7	3	−3·15	−2·08
XIII.	10–16	13·0	− ·302	23·3	+ ·713	24·1	22	2	+6·13	−0·67
XIV.	17–21	19·0	− ·337	16·8	+ ·588	21·9	16	6	+4·84	+1·85
XV.	22–26	24·0	− ·394	13·2	+ ·595	15·4	8	1	−2·13	+1·81

These errors cannot be expressed with sufficient accuracy in terms of the elements of the planet, because of small errors in the solar tables, whence the data for the Sun's elements were derived (see report of the Cape Observatory, *Monthly Notices*, 1894 February), and also because of errors in the perturbations which may be quite sensible. But apart from the error of the lunar perturbation of the Earth, the errors of the tabular place of the planet can be developed in terms of the distance and powers of the time with all requisite accuracy.

Thus we put

$$\Delta\alpha \cos\delta = \frac{1}{\Delta}\alpha + \frac{t}{10\Delta}\beta + \frac{t^2}{100\Delta}\gamma + \frac{t^3}{10{,}000\Delta}\delta + \frac{t^4}{100{,}000\Delta} + l\mu$$

$$\Delta\delta = \frac{1}{\Delta}\alpha' + \frac{t}{10\Delta}\beta' + \frac{t^2}{100\Delta}\gamma' + \frac{t^3}{10{,}000\Delta}\delta' + \frac{t^4}{100{,}000\Delta} + l\mu$$

where Δ is the distance of the planet from the Earth (mean distance of Sun from Earth being $=1$); t, the time, expressed in days, from July $18^d{\cdot}0$; α, β, γ, &c., constants to be determined; l, the effect of the tabular lunar perturbation of the Earth on the tabular places of the planet, as given in the right-hand margin of the table. (These quantities are identical with those used for the dates in question in the computation of the ephemeris.) Consequently, if L′ be the tabular value of the constant of the lunar perturbation of the Earth, the true value of that constant will be

$$L'(1+\mu).$$

Forming normals of the above type, having regard to the weights of the equations, and solving them, we obtain

A. Including all terms ... ... $\mu = +0{\cdot}00786$

B. Excluding terms depending on t^4 ... $\mu = +\ {\cdot}00801$

C. „ „ t^3 and t^4... $\mu = +\ {\cdot}00647$

Substituting these and the values of the other unknown quantities, there result from the three solutions the following residuals in the sense O—C:

	A		B		C	
	$\Delta\alpha\cos\delta$.	$\Delta\delta$	$\Delta\alpha\cos\delta$.	$\Delta\delta$	$\Delta\alpha\cos\delta$.	$\Delta\delta$
	″	″	″	″	″	″
II.	+0·029	+0·001	+0·045	+0·001	0·000	+0·082
III.	− ·030	− ·017	− ·033	− ·017	− ·033	+ ·004
IV.	− ·040	+ ·026	− ·048	+ ·026	− ·028	− ·003
V.	+ ·079	·000	+ ·075	·000	+ ·093	− ·050
VI.	− ·013	− ·010	− ·013	− ·010	+ ·008	− ·056
VII.	− ·050	− ·020	− ·047	− ·020	− ·023	− ·041
VIII.	+ ·032	− ·030	+ ·037	− ·030	+ ·050	− ·033
IX.	+ ·010	+ ·029	+ ·014	+ ·028	+ ·016	+ ·037
X.	+ ·028	− ·017	+ ·032	− ·017	+ ·024	·000
XI.	− ·002	+ ·002	− ·002	+ ·001	− ·024	+ ·034
XII.	− ·051	− ·011	− ·057	− ·011	− ·085	+ ·023
XIII.	+ ·035	+ ·015	+ ·025	+ ·015	+ ·020	+ ·036
XIV.	+ ·012	− ·016	+ ·016	− ·017	+ ·020	− ·028
XV.	− ·025	+ ·011	+ ·012	+ ·010	+ ·027	− ·058

The question as to whether the development of the ephemeris may be legitimately carried beyond the terms depending upon t^2 is still under discussion, but it seems probable that the term depending on t^3 should be included. This, however, does not materially affect the immediate object in view, which is to demonstrate that the *Victoria observations show as great an advance in accuracy on the Mars observations as the Mars observations do on the meridian observations.*

As a further test of accuracy the following are the separate resulting values of the mean Solar Parallax.

Values of the Mean Solar Parallax derived from the separate groups of the Victoria Observations.

Group.	From all observations combined.	Relative Weight.	Omitting the single (small) distances.	Relative Weight.
	″		″	
I.	8·751	0·9	8·751	0·9
II.	·758	15·3	·758	15·3
III.	·807	21·2	·831	15·0
IV.	·833	36·8	·829	36·8
V.	·764	9·9	·767	9·6
VI.	·842	21·3	·777	12·2
VII.	·793	30·7	·783	23·5
VIII.	·842	30·1	·827	15·6
IX.	·727	18·6	·727	18·6
X.	·817	15·7	·731	5·0
XI.	·804	57·3	·800	51·8
XII.	·802	32·0	·753	15·9
XIII.	·826	38·5	·820	26·2
XIV.	·799	28·0	·820	21·3
XV.	·729	12·8	·700	4·2
Mean	8″·804 prob. error ± 0″·0053		8″·794 prob. error ± 0″·0060	

The weights of the observations of single distances have been computed according to the residuals of the individual sets after several approximations. But in the measurement of short distances with the heliometer, small systematic corrections are required, of which the true origin is not yet fully explained, and the law expressing the corrections (though closely representing the observations) is but an empirical one; thus the weights of the short distances, from the point of view of possible small outstanding systematic error, are probably too great.

The equations resulting from double distances are practically free from all systematic error, provided only that the comparison stars are, on the whole, symmetrically situated with respect to the planet, and that the planet itself is indistinguish-

able from the average star of comparison. Both these conditions are realised in the case of *Victoria*.

If the above results are combined with their nominal weights we have from the *Victoria* observations

$$\pi = 8''{\cdot}800,$$

which is equivalent to giving half weight to the single observations, and the probable error is then

$$\pm 0''{\cdot}0057.$$

In the observations of *Sappho* the star places were not connected by triangulation; the parallax has therefore been deduced solely from observations where the angular distance of the planet has been measured from the same pair of comparison stars, on opposite sides of the planet, at observatories in opposite hemispheres. The results are thus independent of the errors of the star places, and practically independent of any other systematic errors.

Values of the Mean Solar Parallax derived from the separate groups of the Sappho Observations.

	Group.	π	Weight.
Sept. 18–22	I.	8″·755	9·91
23–27	II.	·781	13·47
Sept. 28 Oct. 2	III.	·794	12·43
Oct. 10–13	V.	·815	8·61
14–18	VI.	·840	9·43
19–27	VII.	·805	14·21

Group IV., consisting of observations October 3–6, contains only the observations from the stars $t\,x$ available for our purpose. Of these, the star t is a double star (mags. 8·2 and 9·3; $s = 0''{\cdot}9$, $p = 175°$), and it seems doubtful if it was similarly observed in both hemispheres. It is considered safer to reject the observations of Group IV.

The mean result is then

$$\pi = 8''{\cdot}796 \text{ with prob. error } \pm 0''{\cdot}007.$$

If, instead of combining the observations in groups, the parallax is derived from the twenty-two independent determinations, in which a different pair of comparison stars is used for each determination, we get

$$\pi = 8''{\cdot}796 \text{ with prob. error } \pm 0''{\cdot}014.$$

So that some considerable compensation of error is apparently

produced by the combination in groups. We may therefore adopt

From the *Victoria* observations,	$\pi = 8''.800$	prob. error	$\pm 0''.006$
„ *Sappho* „	8·796	„	± ·012
The mean, having regard to weight,	8·799	„	± 0·005

and it is very improbable that this value is one-hundredth part of a second of arc in error.

This value of the solar parallax, combined with Newcomb's value of the velocity of light (299,860 km.), and Clarke's value of the Earth's equatorial radius (6,378·2 km.), gives for the constant of aberration

$$20''.48.$$

Chandler, in his investigation of the aberration constant from existing data, having regard to its modification by his discovery of the change of latitude, finds

$$20''.50$$

for the aberration constant.

On the other hand, Loewy, by his own method, which is independent of the latitude, finds a close approximation to $20''.45$; and Preston, in his discussion of the recent "Talcott" observations for change of latitude, an even smaller value. Loewy's results are independent of the change of latitude, but are seriously affected in their accidental errors (possibly to some extent systematically also) by flexure of the plane mirrors of the equatorial coudé—an instrument not so well suited as one of direct vision for the application of Loewy's beautiful method. The fine series of "Talcott" observations discussed by Preston* is wanting in early morning as well as evening observations; otherwise the result would have had a much greater weight.

Comstock's determination of the aberration constant by a modification of Loewy's method† gives $20''.494 \pm 0''.017$. Of all these recent values, $20''.48$ seems the most probable mean; at least, one cannot conclude that the value of the solar parallax resulting from the *Victoria* and *Sappho* observations is at variance with our existing determinations of the aberration constant and the velocity of light.

Le Verrier's equations for rigorously computing the lunar perturbation of the Earth may be written in the form

$$dr = \frac{m'}{m+m'} \cdot \frac{\pi}{\sin Q} \cdot \cos s' \cdot \cos (\nu' - \odot) \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$r \cdot d\nu = \frac{m'}{m+m'} \cdot \frac{\pi}{\sin Q} \cdot \cos s' \cdot \sin (\nu' - \odot) \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$r \cdot ds = \frac{m'}{m+m'} \cdot \frac{\pi}{\sin Q} \cdot \sin s' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

---

* *U.S. Coast and Geodetic Survey Bulletin*, No. 28.

† *Astronomical Journal*, vol. xi. page 161.

where

Q is the Moon's horizontal parallax at the epoch.

s' „ „ true latitude at the epoch.

v' „ „ „ longitude at the epoch.

r „ Earth's radius vector.

π „ mean solar parallax.

$\odot$ „ Sun's true longitude.

m and m' are the masses of the Earth and Moon.

These expressions are perfectly rigorous, but they may be developed in various ways for computing the lunar perturbation by the use of tables.

To avoid the confusion which may arise from the employment of the principal term of any development of the so-called lunar equation, we shall define the expression

$$L' = \frac{m'}{m+m'} \cdot \frac{\pi}{\sin Q_0} \quad \cdots\cdots\cdots \quad (4)$$

as "the tabular constant of the lunar perturbation of the Earth," where Q_0 is the tabular value of the mean horizontal parallax of the Moon, and the other expressions on the right-hand side of the equation are the tabular values of m' and π.

The new ephemeris of *Victoria* was first computed so that the tabular place of the planet was referred to the centre of gravity of the Earth and Moon; dr, $r \cdot dv$, and $r \cdot ds$ were then rigorously computed for every day by equations (1), (2), and (3), and the resulting values were transformed into $\Delta\alpha$ and $\Delta\delta$ so as to refer the ephemeris to the centre of the Earth.

Since the tabular values of the true radii vectores of the Earth and Moon may be regarded as exact (they are certainly so within $\frac{1}{5000}$th part of each), the true values of dr, $r \cdot dv$, and $r.ds$, computed from the tabular values, may always be expressed by

$$(1+\mu)\, dr, \quad (1+\mu)\, r \cdot dv, \quad (1+\mu)\, r \cdot ds,$$

and the constant of the lunar perturbation of the Earth will be

$$L = L'(1+\mu). \quad \cdots\cdots\cdots \quad (5)$$

The tabular values employed in the new ephemeris were

$$\pi = 8''{\cdot}880; \; m' = \frac{1}{83}, \text{ or } \frac{m'}{m+m'} = \frac{1}{84}; \; Q_0 = 3423''{\cdot}0.$$

Substituting these values in equation (4) we obtain

$$L' = 6''{\cdot}3705.$$

Hence, by equation (5),

	Solution A.	Solution B.	Solution C.
$L = L'(1+\mu) =$	$6''{\cdot}421$	$6''{\cdot}421$	$6''{\cdot}412$.

Thus the resulting constant of the lunar perturbation of the Earth will be

$$6''{\cdot}42$$

if terms higher than the square of the time are employed in determining the errors of the ephemeris, or

$$6''{\cdot}41$$

if the same development is limited to the square of the time.

Pending the definitive discussion of this point, and adopting

$$L = 6''{\cdot}42$$

we have

$$\frac{m'}{m+m'} = \frac{L \sin Q_0}{\pi} \quad \ldots\ldots\ldots \quad (6)$$

where all the quantities should be true values.

Now Q_0 is probably accurate within $\frac{1}{5000}$th part; π, as determined from the preceding observations, nearly within $\frac{1}{2000}$th part; and L (not yet definitively fixed), about $\frac{1}{600}$th part.

Substituting the known values of Q_0, and the above-mentioned values of L and π, we have, from equation (6),

$$\frac{m'}{m+m'} = \frac{1}{82{\cdot}59}$$

and

$$\text{the mass of the Moon} = \frac{1}{81{\cdot}59},$$

of which the probable error is about $\frac{1}{500}$th part.

In the face of such results it is evident that the time has arrived when astronomers should reconsider their methods of work. Future geometers are entitled to expect from the practical astronomer positions of the exterior planets five times more accurate than those at present available, and it may be well to consider the means by which such expectation can be best satisfied.

The keynote to the first advance towards this end will unquestionably be found in the spirit which has led to the success of the Astrophotographic Congress, and of the above-quoted observations of *Victoria*, viz., the international co-operation of all observatories that are occupied with astronomy of precision.

In the case of *Victoria*, twenty-two different meridian observatories co-operated in determining the places of the stars of comparison. The observatories at Göttingen, Yale, and the Cape, undertook the heliometer observation of the comparison stars, and heliometer observations of the planet itself were made

at Leipzig, Yale, Göttingen, Bamberg, and the Cape of Good Hope. Dr. Auwers also came from Berlin to take part in the observations at the Cape.

For determining important fundamental constants, like the solar parallax and the lunar equation, the highest available precision is requisite; hence the necessity for the large amount of concentrated activity on this special research. But in this case the highest precision is only required in the *relative* positions of the stars to each other and of the planet to the stars, but a like precision in the *absolute* place of the system of stars, regarded as a group, is not necessary.

The accuracy attainable in the *absolute* positions of planets is limited by the unavoidable systematic errors of our fundamental stars. At the present moment this uncertainty for any fundamental star amounts at least to $\pm 0''.3$; ultimately we may hope to reduce this uncertainty to $\pm 0''.1$. For determinations of the planet's position relative to surrounding stars, an accuracy of $\pm 0''.1$ will therefore probably suffice, and such precision can be attained for any epoch with perfect certainty by heliometer observations on three or four nights (that is to say, for the outer planets), provided that the absolute positions of the comparison stars are well enough known.

But by whatever process the position of the planet is referred to the comparison stars, and the relative position of these stars to each other is determined, their fundamental system of right ascension and declination must be ultimately referred to observations of the Sun. Thus, so far as our present knowledge and experience go, the basis of all our work must still be dependent on meridian observations with the transit circle or with some modification of that instrument in or out of the meridian.

One of the first steps, therefore, which it is desirable that astronomers should attentively reconsider is, How can the determination of absolute places of the fundamental stars be best improved? that is to say, by what method, or combination of methods, can we best arrive at the following problems?—

1. The determination of fundamental declinations, including, of course, the mean absolute latitude and the change of latitude of each fundamental observatory.

2. The elimination of the systematic error in observations of the Sun, which at present is due partly to personal error of the observer both in right ascension and declination, partly to the heat of the Sun's rays, which produce irregular expansion in the instrument employed.

3. The elimination of periodic errors in the right ascensions and declinations, or of errors depending on the brightness of the stars or on the direction of their apparent motion across the field of view.

In none of these respects does the present state of practical astronomy respond to the requirements of the problem. It is

true that every additional co-operating observatory (*especially if situated in the Southern Hemisphere*), every sound, independent method of observation, every systematic series of fundamental observations in the past or future, tends to strengthen the fundamental basis of our science.

But have these efforts in the past been thoroughly systematised so as to insure the best result from their combination? Has the work been so partitioned and systematised as to give the greatest efficiency for the labour expended? Have the instruments and observatories been so designed and employed as to afford, by their manner of construction, of employment, and of situation, the most perfect elimination of all sources of error? Have photographic and other automatic methods of registration yet been fully utilised in fundamental work?

To these and many kindred questions the answer must be in the negative.

If a new era of precision is to mark the progress of astronomy in the coming century, these questions should closely occupy the minds of astronomers in the immediate future, and the resulting suggestions be published, criticised, and made the subject of experiment.

In this way, preparation may be made for more perfect international co-operation, with better methods, better organisation, and more economy of labour in the common work.

Assuming that by some such means we shall arrive at the requisite precision in the places of the fundamental stars, it may be well to consider some of the further points raised by Professor Newcomb.

Before any satisfactory answer can be given as to the possibility of determining the position of *Mercury* and *Venus* by heliometer observations, it would be necessary to make special experiments. Having regard to the smallness of the disc of *Mercury*, the method of pointing by placing the image of the comparison star in the centre of gravity of the gibbous disc, or by bisecting the imaginary line joining the horns of the crescent, promises considerable accuracy. Such observations can only be secured in the exceptional conditions when the planet is within 2° of a star as bright as the 3rd or, in some circumstances, as the 4th magnitude. With *Venus*, especially in low latitudes, much fainter comparison stars might be similarly employed when the planet is not too near the Sun.

But it is unquestionably in observation of the outer planets that the greatest advance is possible. For *Mars*, *Jupiter*, and *Saturn*, the photographic method will probably prove far less satisfactory than heliometer observations; not that the difficulty suggested by Professor Newcomb (the fogging of the plates and the blotting out of the images of surrounding stars) may not be easily overcome, but because sharply-defined photographic images of such objects (i.e., whose limbs are capable of sharp bisection) cannot be obtained; at least, so far, this is the writer's

experience. The relative positions of *Jupiter's* satellites can, however, be determined with great accuracy by photographic methods. The minor planets, as well as *Uranus* and *Neptune*, may be photographically observed, probably with all desirable accuracy and with less labour than with the heliometer.

At present, however, there seems to exist no entirely satisfactory evidence on the latter subject, at least there is no published investigation in which the distortion of a photographic objective has been fully and satisfactorily worked out so as to show the law of distortion in terms of the distance from the centre of the plate, and also whether this distortion is the same in all radii. Bessel (*Königsberger Beobacht.* Abth. 5, p. iv.) found non-symmetric distortion in the field of the one object-glass which he fully investigated (see also *Encyclop. Britannica*, vol. xvi., Art. "Micrometer," p. 251), and some results of Jacoby's recent measurements of photographic plates appear to point to the existence of similar errors.

When this question has been fully worked out for any particular instrument (as may be comparatively easily done by photographic observation of the *Victoria* comparison stars), that instrument would probably be suitable for use, not only for the observation of *Uranus*, *Neptune*, and the minor planets, but for the triangulation or interconnection of the stars of comparison by micrometric methods.

Professor Newcomb's proposed photographic heliometer has claim to further study. It has the advantage of eliminating some of the errors due to optical distortion in the ordinary photographic method, and of personality in the observer's habit of pointing in the ordinary heliometer method. But it is very questionable if the photographic images, especially of planets, are capable of measurement with the same accuracy as the visual images. The proposed instrument has the same disadvantage as the ordinary heliometer, viz., that by one observation only one result is secured; whereas, by the ordinary photographic method the relative positions of all the available comparison stars on the plate are obtained; the proposed method also involves additional labour to that of ordinary heliometer observations, viz., the after labour of measuring the plates.

So far as can be judged from published photographs of test diagrams, there is a new form of photographic objective called the "Doppel-Anastigmate," which has been developed by Dr. C. P. Goerz, of Berlin. If this lens be adapted or modified for the photography of infinitely distant objects, it will offer great facilities for securing nearly perfect pictures over a very large field. If experiments on stars confirm this expectation, and if images of stars capable of being pointed upon with a probable error of a tenth of a second of arc at 3°, 4°, or 5° from the centre of the plate can be obtained, it would repay almost any amount of labour to investigate thoroughly the distortion errors of such a lens, and to apply it in combination with meridian

observations to a thorough triangulation and discussion of the positions of all zodiacal stars necessary for our further purposes. If such a lens can be found, the scheme can be very readily reduced to a practical form.

In observations of the Moon a decided advance seems possible, because the libration, thanks to the recent researches of Dr. Hartwig and Dr. Franz, is now known with great accuracy, and consequently the position of a well-defined spot near the Moon's centre can be referred to the limb (or, rather, to the centre of the Moon) with almost any desired precision. The position of this spot can then be referred to surrounding stars within 2° of the Moon's centre, with almost any desired precision, by means of heliometer observations. Observations by this method, however, would be limited to epochs within three or four days of full Moon, to avoid the possibility of apparent change in the position of the spot produced by change in the direction of illumination, unless, indeed, the positions of two other spots—one nearer the preceding, the other nearer the following, limb—can be also accurately referred to the Moon's centre. For observation in the Moon's first and last quarter, a great addition should be made to the list of occultation stars, and the necessary predictions of phenomena be computed for such observatories as are prepared to undertake the observations. Hardly sufficient attention appears to have been given to the accurate results obtained in this way by Dr. H. Battermann in his paper, "Beiträge zur Bestimmung der Mondbewegung und der Sonnenparallaxe aus Beobachtungen von Sternbedeckungen am sechsfüssigen Merz'schen Fernrohr der Berliner Sternwarte." The reduction by Dr. Ludwig Struve of the observations made at many different observatories, of the disappearance and reappearance of stars at the Moon's limb during the total eclipses of the Moon in 1884 and 1888, on plans proposed and elaborated by Dr. Döllen, reduces the outstanding error of the Moon's occultation diameter within very narrow limits. Future eclipses, similarly observed, will strengthen the determination. Dr. L. Struve's results, however, point clearly to the desirability of confining the observations to stars not fainter than the 8th magnitude.

Finally, we shall ere long have from the hands of Professor Newcomb a new series of homogeneous astronomical constants based on a complete discussion of all existing data, and new and more accurate tables of the planets similarly founded. Here also is the basis of a new departure!

Has not the time, therefore, arrived when practical steps should be taken to render the labour of those who undertake future work like that of Professor Newcomb, not only less laborious, but more satisfactory, than it has been in the past?

The ideal condition is that the geometer should not be required to undertake (as Professor Newcomb had to do) the reduction of vast masses of incongruous material to a homo-

geneous system—that it should be the business of practical astronomers so to arrange the methods and the partition of their work that their combined efforts shall produce all requisite results in a complete and uniformly digested shape for the purposes of those engaged in researches in astro-dynamics.

No one who has fully considered the subject, and experienced the earnest desire, which happily prevails amongst astronomers, to devote themselves to such work as that by which, with the means and opportunities at their disposal, the progress of science may be best advanced, can doubt that, by organised and combined effort, much greater things can be accomplished in the future than have been in the past.

To bring these general remarks to a practical conclusion, the following questions may be asked :—

1. Whether, in the opinion of astronomers generally, steps should be taken for a more complete and harmonious organisation and partition of the astronomical work of the world from the year 1900.

2. Are astronomers prepared to enter upon preliminary study, discussion, and experiment on the practical methods by which the art of observation may be raised to a higher level of accuracy, and its results be derived and published in a more systematic and homogeneous system ?

3. If these questions are answered in the affirmative, would it be desirable to hold an International Astronomical Congress, say in 1896, to discuss and make the necessary preliminary arrangements, and then let the definitive programme and partition of work be made at another general congress to be held in the year 1899 ?

Royal Observatory, Cape of Good Hope,
1894 *March* 16.

Note on Star Corrections in N.P.D. By W. E. Cooke.

(*Communicated by the Secretaries.*)

In a letter to the Astronomer Royal, dated 1894 January 23, Sir Charles Todd, the Director of the Adelaide Observatory, writes:—"Anything which will facilitate the reduction of our observations is so important that I shall not apologise for submitting to you a simple method which my first assistant, Mr. W. E. Cooke, M.A., has devised for reducing our Z.D. observations to mean N.P.D. January 1, respecting which I shall be glad to have your valuable opinion, and should it be favourable it may be brought before the Royal Astronomical Society."

The letter and notes on the method were handed by the Astronomer Royal to the Secretaries, who have drawn up the present note on the method.

The star correction in declination is, according to Bessel's notation,

$$Aa' + Bb' + Cc' + Dd',$$

where

$$a' = \tan \omega \cos \delta - \sin \alpha \sin \delta, \quad b' = \cos \alpha \sin \delta,$$
$$c' = 20''{\cdot}0524 \cos \alpha, \text{ and } d' = -\sin \alpha.$$

Of this expression part depends on both α and δ, part on α alone, and part on δ alone, as is seen by the alternative form of the correction tabulated in the *Nautical Almanac*, viz.:

$$i \cos \delta + g \cos (G + \alpha) + h \cos (H + \alpha) \sin \delta.$$

The procedure adopted by Mr. Cooke is (1) to leave untouched the computation of the part depending on both α and δ, i.e.,

$$h \cos (H + \alpha) \sin \delta,$$

or in the other notation

$$-A \sin \alpha \sin \delta + B \cos \alpha \sin \delta,$$

which is performed by the additions of two sets of three logarithms; (2) to simplify the computations of the other parts by tables and diagrams. The part $g \cos (G + \alpha)$ or $Cc' + Dd'$ is tabulated for each hour of R.A. and for every ten days throughout the year. On each night the values of this quantity are plotted in a curve for the hours of R.A. occupied in observation, and from this curve is read off the value of the term for every star in turn. Similarly, the part $i \cos \delta$, or $A \tan \omega \cos \delta$, is tabulated for every 10° of declination and every ten days throughout the year, a curve being constructed for each night of observation from the tables. These tables are of universal application, and if adopted at other observatories it might be advisable to extend them considerably.

It should be remarked that constants are added at various parts of the work to obviate the use of algebraic signs.

On Star Corrections. By Professor H. H. Turner, M.A., B.Sc.

1. The foregoing paper by Mr. Cooke affords an opportunity for putting down some notes on this subject, which has occupied my attention at intervals for some years past.

2. To the end of the year 1885 star corrections were computed at the Royal Observatory, Greenwich, by means of Airy's constants and day numbers, which were essentially those of Bessel, slight modifications being made so that algebraical signs were avoided. The day numbers were printed in the *Nautical Almanac* to the year 1890, but discarded when it was known that they were no longer required at Greenwich. The "star constants" were printed in the Greenwich Catalogues up to and including the Nine Year Catalogue 1872; and their computation was a serious addition to the labour of constructing the Catalogues.

3. There were several reasons for making a change, but the two chief were—

(*a*) The adopted procedure was found to be cumbersome.

(*b*) The use of the so-called "star constants" from year to year was found to be a fruitful source of errors, both because the numbers were not really "constants" and their slow change were apt to be neglected too long, and because errors were made in copying.

4. From 1886 January 1 Mr. Stone's "Tables for facilitating the computation of star constants" have been regularly used. All the computations are made independently in duplicate, and the results compared. A time about equivalent to the whole time of two computers is thus occupied in the computation of star corrections. If the meridian observing were in any way distributed in zones, this labour might of course be considerably reduced; but distributed, as it is at Greenwich, to all zenith distances indiscriminately, there is no way of reducing the labour except by simplifying the processes, if possible.

5. Mr. Finlay, in *Monthly Notices*, vol. l. p. 497, gives a method which certainly has advantages, and Mr. W. E. Cooke's method, given above, also seems to me to be a distinct simplification. My only doubt is whether the advantages gained in either case are quite sufficient, say, to make a change at Greenwich desirable. At the same time the question of saving labour is one of great importance, and the matter cannot be too thoroughly discussed. I have tried various methods during the last few years; in the first instance various forms of tabulation, which after many trials were found to be too cumbrous; and latterly different mechanical devices. At least four mechanical devices have been tried with fair success, as shown by models in wood and paper; but I do not propose to call attention here to more

than one of these—the last and simplest—which I hope will prove efficient.

6. The star corrections in R.A. and Decl. $\Delta\alpha$ and $\Delta\delta$ may be written, as on p. 297 of the *Nautical Almanac* for 1894,

$$\Delta\alpha = f + g \sin(G+\alpha) \tan\delta + h \sin(H+\alpha) \sec\delta \quad . \quad . \quad . \quad . \quad (1)$$

$$\Delta\delta = i \cos\delta + g \cos(G+\alpha) + h \cos(H+\alpha) \sin\delta \quad . \quad . \quad . \quad . \quad (2)$$

and the first of these equations may be written

$$\Delta\alpha \cos\delta = f \cos\delta + g \sin(G+\alpha) \sin\delta + h \sin(H+\alpha) \quad . \quad . \quad . \quad (3)$$

the expression on the right being now similar to that of equation (2).

Now all the terms in equations (2) and (3) may be represented under the form

$$p \sin(P+\alpha) \sin\delta,$$

where sin δ is in some cases unity, i.e. δ may be put permanently equal to 90°. Thus a mechanical device which will give such a term at sight by setting for α and δ (p and P being set at the beginning of the series) would save the labour of entering three logarithms, adding, and taking out antilogs. There is, of course, nothing new in the principle of such devices; it only remains to settle the details, and I propose the following arrangement:—

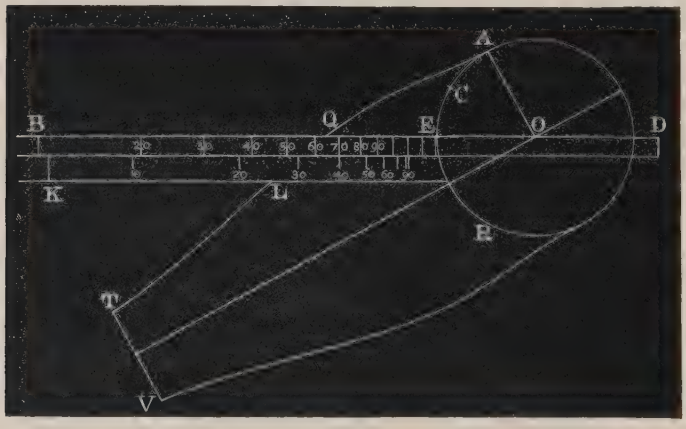


Fig. 1.

7. A graduated circle ACR can turn about O on a plate TAV. The point C is the zero, and R.A. is set off in the direction CR. The arc CA is set equal to the angle P (representing either G or H in the star corrections) and the circle then clamped to the plate. The plate and circle can now be turned about O until CE reads the R.A. of any particular star; and

thus the arc AE=(P+α). The plate VAT is so constructed that on any radius, OQ, the part EQ outside the circle is proportional to log cosec AE, or $-$ log sin AE. So that if on a scale BD, BE represent log p, then

$$BQ = BE - EQ = \log p - \log \operatorname{cosec} AE = \log p \sin (P + \alpha).$$

If, further, another scale KL slide along BQD, and be graduated proportionally to log sin δ from left to right; and if the point corresponding to 90°, where

$$\log \sin \delta = 0,$$

be brought vertically under Q, then if S be a point on the scale BD vertically over the point for declination δ on KL, we shall have

$$\begin{aligned} BS &= BQ - QS \\ &= \log p \sin (P + \alpha) \sin \delta. \end{aligned}$$

The operations thus consist of the following:—

(a) *Preliminary*, applying to the whole of a set: Turn the circle on the plate until AC=P, and clamp circle on plate. Slide BD until the point corresponding to p is on the limb of the circle and clamp BD. It would be well to have lenses or even microscopes, at least for these permanent settings.

(b) For any star α, δ: Bring α to E, the edge of BD; set the 90° mark on KR under Q, where the plate cuts BD, and read off the point S on BD vertically over δ. There should be no difficulty in doing this if BD be graduated on both edges.

8. This being the general principle several small modifications of detail suggest themselves. In the first place we have *two* terms involving G and g and two involving H and h. Consider the first. If we have a scale B′D′ precisely similar to BD but at right angles to it, and cutting the circle in E′, the plate in Q′ &c., then if

$$\begin{aligned} BQ &= g \sin (G + \alpha) \\ B'Q' &= g \cos (G + \alpha). \end{aligned}$$

Thus the two terms g sin (G+α) sin δ, required for $\Delta\alpha$ cos δ, and g cos (G+α), required for $\Delta\delta$, can be read off at one setting. Similarly writing (H+90°) for G, the other two terms can be found at one setting. No subsidiary scale KLR is necessary for the scale B′D′, since sin δ only occurs in one term of each pair.

Secondly, in all logarithmic scales there is a great inconvenience arising from the length to which they extend for the small quantities. The length for the portion 0·1 to 1·0 is as great as that from 10 to 100, or from 100 to 1,000, and is, of course, precisely similar. We can thus take advantage of this fact by using the same portion twice or three times over, always remembering to divide by 10,

or 100, or 1,000, as the case may be. Thus the plate VAT is terminated abruptly at T, whereas it should really

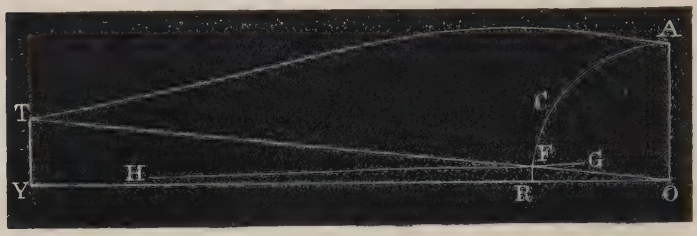


Fig. 2.

extend to infinity. The point T corresponds to the angle 5° 44′, whose sine is 0.1. If OT cut the circle in F, and GFH be drawn so that excess of radius vector is proportional to log. cosec (angle) − 1, or log. $\left(\frac{1}{10}\text{ cosec angle}\right)$, instead of log. cosec (angle), then the curve GFH will read off on the scale

Fig. 3.

BQD *ten times* the corresponding term, and may be used for small angles. Similarly another curve may be drawn reading off *one hundred times* the term for smaller angles still.

Again, the scale for δ need not be of more than a moderate length; it need not, in fact, extend beyond 5° 45′ if below the portion 90° − 5° is placed another portion corresponding to log. (10 sin δ) or 1 + log. sin δ instead of sin δ, and below this another corresponding to log. (100 sin δ) or 2 + log. sin δ. The scale BD need thus not be extended beyond modest limits. I think convenience would be sufficiently consulted, and sufficient accuracy attained, by making the portion from log. 10 to log. 100 equal to one metre, though a smaller contrivance than this might answer.

9. The above was already in type when a series of simpler contrivances suggested themselves, which promise to be many ways more efficient. It will, I think, be of interest to describe four successive devices which are all comparable in efficiency, though the last will probably turn out the best. The

use of a logarithmic scale, with the inconveniences detailed in paragraph 8, is discarded in the following apparatus.

10. On a drawing board VQ (fig. 1) are drawn a series of "curves of sines" AC_1B, AC_2B, AC_3B, &c., the maxima OC_1, OC_2, OC_3, &c., being respectively 30, 29, 28 . . . , 2, 1, 0 units —say, half-inches—and representing 30″, 29″, 28″ . . . , 2″, 1″, 0″. The base AB being divided uniformly from 0^h to 12^h, as at DE,

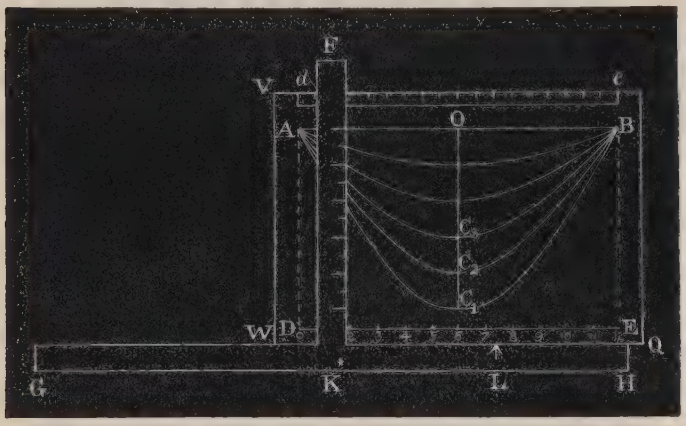


Fig. 4.

or from 0° to 180°, as at *de*, ordinates to any one of the curves, say, maximum 28″, give the values of 28″ sin a for the various R.A.'s or angles from 0^h to 12^h; and a T square FGKH whose T slides along the base WQ of the board, and whose edge FK is graduated uniformly, may be used to read off the value of this quantity by noting the point where the curve 28″ cuts its edge when slid to the proper R.A. If the value of 28″·3 sin a is required, we must interpolate between the curves for 28″ and 29″, either by eye or by actually drawing the 10 intermediate curves, which is not difficult on the scale suggested. Thus we see how to read off p sin a, where p has any value from 0″·0 to 30″·0. To read off p sin $(P+a)$ we merely alter the index on the T square from K to some other point L such that when L points to a, K points to $(P+a)$, or $LK=-P$. Thus L is constant in position for the day. An ink mark on a piece of paper gummed temporarily to GH would be an adequate index.

Now to form p sin $(P+a)$ sin δ we merely move the square to δ (taking now the top scale *de* divided in degrees) and read off the value of the curve whose maximum is p sin $(P+a)$, as already found.

When once the curves are nicely drawn this makes a very efficient machine. Its one drawback is the difficulty of following the curves, when these are numerous enough to give sufficient

accuracy. To obviate this the apparatus of the next paragraph was devised.

11. Instead of many curves, a single curve AC_1B would be sufficient if we could vary the scale on FK so as to make it read p units at the point C_1. Now a scale can be varied by the device used in the "diagonal scale." If the line OA (fig. 5) be divided

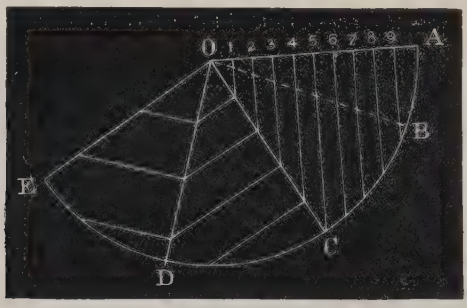


Fig. 5.

into ten equal parts, and perpendiculars be erected to OA at each point, then any other radius OB of the same length as OA will be divided uniformly into a smaller number of parts. For

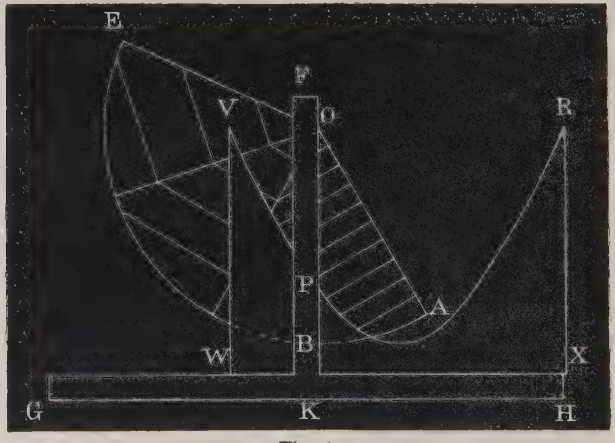


Fig. 6.

convenience new perpendiculars may be drawn at any other radius OC, OD, &c. Let us call a circular sector so divided a "reducing scale." Thus if FGH (fig. 6) be again our T square, and a reducing scale OAE be pivoted at O on the edge FK, then the maximum ordinate OB can be divided into any arbitrary number of parts p by rotating the reducing scale. Let us now cut out of card a single sine curve VAR,

which may be slid beneath the arm FK of the T square, the edge WX of the card bearing against the T of the square. Then the ordinate OP will be $p \sin (P + \alpha)$, as before, if the index be adjusted so that $(P + \alpha)$, and not α simply, be read off on the sliding scale.

12. So long, however, as we use a *slide* for setting in R.A. we get the sine curve entering into the machine. If the R.A. is to be set off on a uniform scale—which is practically a necessity if we are to form the sum $(P + \alpha)$ mechanically—we are limited to two methods—those of translation and of rotation. It is curious that I should have dwelt so long upon the *slide* for R.A., for the graduated circle is obviously more appropriate. But one seldom thinks of the simplest thing first, and it was not until I had made one or two machines of the above type that it struck me to try setting off the R.A., not on a straight line, but on a circular arc. The curve now to be used is no longer

$$y = a \sin x + b,$$

but

$$r = a + b \sin \theta,$$

where a and b are constants. It is obviously simplest to take $a = 0$, when the curve is a circle and can be described mechanically with great ease. The apparatus now becomes modified as

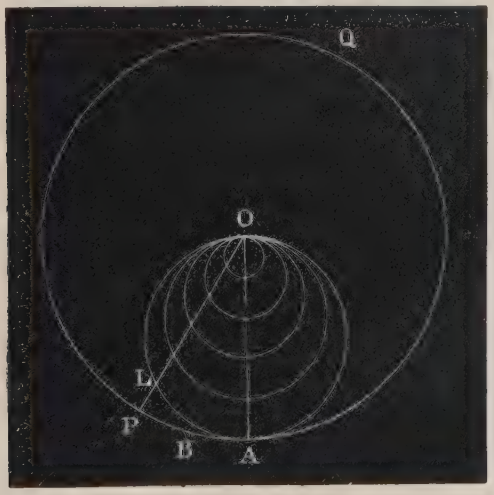


Fig. 7.

follows: The R.A. or declination is set off on the rim of a circle APQ, but so that the zero point can be shifted arbitrarily to any point B, where AB is made equal to P. A series of circles are described, all passing through O, and with diameters 30″, 29″, 28″, &c. . . . . 2″, 1″, corresponding to the series of sine curves in paragraph 10 (fig. 7). Then if $BP = a$, so that $AP = P + a$, it

is easily seen that OL=OA cos (P+α), and the value of p cos (P+α) can be readily found by tracing the circle corresponding to the value p up to the radius OP, which should be a divided scale.

13. But finally the circles need not be actually drawn, and herein consists the great simplicity of what I believe to be the final device. If OT (fig. 8) be the length p, and if OP be a straight-edge, and a set-square MLK be slid along OP so that the edge

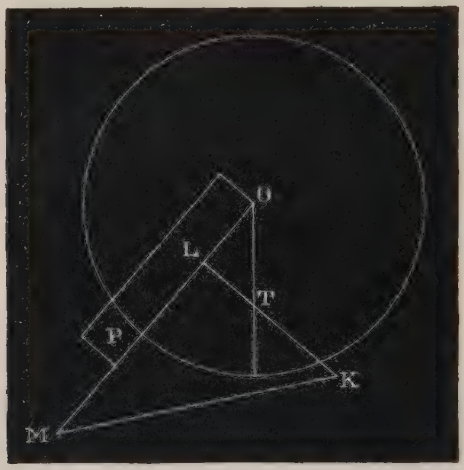


Fig. 8.

LK passes through T, then obviously OL=OT cos (P+α), LT=OT sin (P+α); in fact, we have arrived by a roundabout route at the very simplest method of finding the sine and cosine required by actually constructing the triangle of which they are the sides, viz. OLT. The final machine I suggest is, therefore, as follows (fig. 9). I describe it in terms of wood and paper, though a more exact apparatus can obviously be made in metal.

On a drawing board covered with white paper a circle is drawn, and carefully graduated. (It is convenient to have graduations extending from the point A in the direction AD in degrees, and in the direction AE in hours and minutes.) A straight-edge POP′ is pivoted at O on its edge (a piece of paper may be gummed on in order to make a hole for the pivot), and graduated uniformly from O outwards. A set-square MLK, graduated on one edge LK, completes the apparatus. (The edge LK should also be graduated *on the back*, so that the set-square may be reversed if necessary. The straight-edge may be reversed by simple rotation.)

To form the terms p sin (P+α) and p cos (P+α) first find the position of the point T for the day by turning the scale OP

to the point D, where AD=P, and setting off OT=r. Then, when OP is turned to any right ascension α, where AE=α, we have EOD=(P+α), and if the set-square be slid up to the point T the distances LT and OL, which can be at once read off the scales, are the quantities required. The point T may be marked

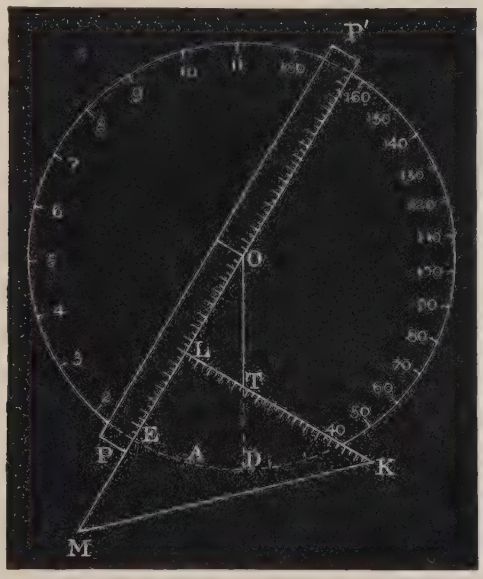


Fig 9.

for the day by an ink dot. The successive positions of these dots will form a curve which may be laid down on the paper for a whole year, and dates attached to the proper points.

14. This brief description of the machine will probably be sufficiently intelligible, and, as I have not yet had an opportunity of trying it thoroughly in practice, any practical comments are more fitly reserved for a future occasion. But I cannot but think that a simple apparatus of the kind will at least be found of great use in *checking* computations, though it may be advisable to make the computations originally in figures.

Graduating Wedges. By Captain W. de W. Abney, C.B., R.E., D.C.L., F.R.S.

In some cases where wedges are very opaque it becomes difficult to arrive visually at the correct graduation, as light from an ordinary source, such as a lamp, will not pass through with sufficient quantity to enable an accurate measure to be made. The light which it seems most desirable to employ is the electric (arc) light, since it is far more luminous than a lamp or candle, and it has the advantage that a large quantity of light is emitted from what is practically a point. There are, however, variations in the electric (arc) light from time to time, and unless the comparison light, with which the relative intensities passing through different parts of the wedge are measured, varies at exactly the same time and in the same proportion, the measurements will often be very much out. If we merely wish to measure the white light transmitted, the apparatus to employ is not very extensive, and fig. 1 will show what it is. EL is the electric light placed in a lantern or box of some kind, to prevent the room, which should be slightly darkened, from being flooded with bright white light. L_1 is a condenser which

Fig. 1.

throws an image of the crater of the positive pole upon the slit S of the collimator C. The rays issue parallel and are caught by a lens L_{III}, which forms an image of the slit upon the surface of the wedge W, placed in a proper position and in its mountings. The light after passing through the wedge forms a circle of light on the screen. It will be noticed that the image of the slit may be as narrow as one wishes by opening or closing S, and that we have a line of light passing through the wedge, such as is required to effect the graduation. Calculation will show that with a fairly narrow slit the measured intensity passing through it may be taken as that passing through the mean thickness of that part on which the image falls.

Placed in the path of the beam, and between the wedge and L_{III}, is a plain mirror M (for which I often substitute a prism of $1\frac{1}{2}°$, and so obtain a single reflection), which reflects the light at right angles, or any convenient angle to its path. It is again

reflected from M_1, a silver on glass mirror. An image of the slit is formed in the path and a second disc is formed on the screen. The centre of this disc is made to coincide with the centre of the disc formed by the light passing through the wedge. A rod R is placed in the path of the two beams, which casts two shadows, one illuminated by one beam and one by the other. The usual black mask is used on the screen, to confine the attention to a small part of the shadows.

It will be seen that when any variation takes place in the light it equally affects both the illuminated shadows; hence the measures may be made without fear of error creeping in. Sectors with apertures, movable at will whilst they are rotating, are introduced, as shown in the figure, and sometimes a second set of fixed sectors are introduced between M and W should the light passing through W be too bright. The screen is placed perpendicular to the line bisecting the angle made by the two beams. It should be noted that this plan almost necessitates movable sectors, but sectors which are fixed at known apertures can be used at a pinch, and the balance made by moving the wedge in its settings.

It should be remarked that though the wedge may not be pure black the readings can be very readily made by the method of oscillating between "too light" and "too dark" for the

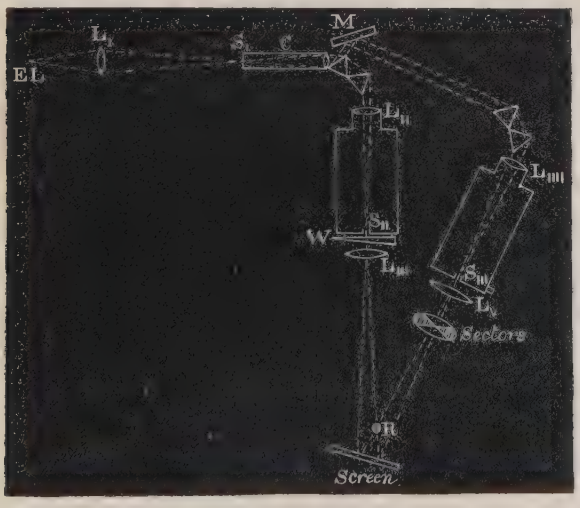


Fig. 2.

shadow whose brightness is controlled by the sector. In making a valuation of the wedge, the first thing to do is to compare the lights without the intervention of the wedge, and then to take readings.

For certain purposes it is necessary to know how much of each colour of the spectrum is transmitted through a wedge, and fig. 2 shows how this is accomplished.

The electric light and the collimator are placed as before, but the parallel emergent rays fall upon a pair of prisms, and the spectrum is brought to a focus by L_{II} on to a screen in which there is a slit against which the wedge in its setting is placed. The slit can be placed in any spectrum ray, and the wedge surface is always kept perpendicular to that ray. A lens L_{III} brings the rays to a focus, so that a monochromatic image of the surface of the last prism is formed on the screen. From the surface of the first prism parallel rays are reflected: these are caught by a mirror and fall on a pair of precisely similar prisms, and the remainder of the apparatus is exactly the same as that described above, a second patch of coloured light being formed over the first patch. The slit S_{III} is so adjusted in the spectrum that the two patches are of the same colour. The sectors are placed as shown in the figure, the rod R forming two shadows, as before. The method of procedure is to place the slit S_{II} in some colour in the spectrum, and S_{III} in the same. The wedge is then graduated for this beam throughout its length, another position is taken up and the same process gone through. By this means we get the logarithmic factor of transparency for each part of the wedge for the whole of the spectrum colours. As I have mentioned in another paper, the factor most essential to know for extinction purposes is that for the part of the spectrum near the Fraunhofer line E.

Photograph of the Cluster M. 46, *and of the Nebula* H IV. 39 *Argûs*.
By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster M. 46 and of the nebula H IV. 39 *Argûs*, R.A. $7^h\ 37^m$, Decl. 14° 30′ south, was taken with the 20-inch reflector on 1894 February 24, with exposure of the plate during 90 minutes, and the copy now presented is enlarged to the scale of 1 millimetre to 24 seconds of arc.

The cluster is No. 2437 in the *New General Catalogue*, and 1564 in the *General Catalogue*. The nebula is No. 2438 in the *New General Catalogue*, and 1565 in the *General Catalogue*.

Sir J. Herschel describes the cluster as a remarkable object, very bright, very rich, very large, with a planetary nebula involved, which he describes as pretty bright, pretty small, extremely little extended, barely resolvable.

Lord Rosse (*Phil. Trans.*, 1850, p. 513, Pl. XXXVIII., fig. 12, and *Observations of Nebulæ and Clusters of Stars*, p. 61) records twenty-one observations of the nebula made between the years 1848 and 1876. He saw it first as a planetary nebula 60″ in diameter, and subsequently as an annular nebula with two stars, and a suspected third star, in it. Much uncertainty as to the character of the object is shown by the records, and in

the last observation (1876) he says, "It can hardly be called a planetary nebula."

The star *n.p.*, the centre, is estimated as of 13th–14th magnitude, and the other star near the *following* edge 16th magnitude.

Lassell (*Mem. R.A.S.*, vol. xxiii. p. 60, Pl. II. fig. 5) describes it as a planetary nebula, and saw two stars in it.

The photograph leaves us in no doubt as to the character of the nebula. It is an annular nebula, as perfect in outline as M. 57 *Lyræ*, and is seen projected on a plane facing the eye and circular in form. The ring is most condensed on the *n.f.* side, but no distinct central nebulosity is shown, and there are three stars in the interior: the brightest of them (13th–14th magnitude) is near the centre; another, of about 16th magnitude, is on the *s.p.* side; and the third, which is below 16th magnitude, is almost involved in the ring on the *s.f.* side. There is also evidence of very faint condensations of nebulosity in the ring itself.

The nebula, as the photograph clearly shows, is either involved or else in alignment with the northern part of the cluster, which is a magnificent aggregation of stars between 9th and 16th magnitude, and the photo-fields around it are crowded with stars having the usual remarkable groupings, and numerous apparent double, triple, and multiple stars. Some years hence these rich photo-fields of stars and their groupings will afford delightful studies for our successors by the aid of photography.

Photograph of a "New" Spiral Nebula in Perseus. By Isaac Roberts, D.Sc., F.R.S.

The Spiral Nebula is in R.A. $2^h\ 29^m\ 58^s$, Dec. 38° 31′·4 *north*, Epoch 1895. It is $3^m\ 51^s$ *preceding* and 5′·4 *south* of H_3 I. 156 *Persei*; both nebulæ are visible on the same photograph.

I assume this nebula to be new to science for the reasons that it is very faint, and is not recorded in the *New General Catalogue* or in the supplement to it, a manuscript copy of which Dr. Dreyer kindly sent me.

The convolutions of the spirals are very faint, but clearly visible on the negative, and involved in them are four 14–15 mag. stars and 6 or 7 stars, or star-like condensations, less bright than 16th mag. The convolutions are symmetrical, and proceed from a very faint star-like nucleus.

Photograph of the Nebula H_3 I. 156 *Persei.* By Isaac Roberts, D.Sc., F.R.S.

The photograph of the nebula H_3 I. 156 *Persei*, R.A. $2^h\ 33^m\ 49^s$, Dec. 38° 36′·8 *north*, was taken with the 20-inch reflector on 1893 December 29, with exposure of the plate during three hours, an enlargement of which to the scale of 1 millimetre to 24 seconds of arc is now presented.

The nebula is No. 1023 in the *New General Catalogue* and 575 in the *General Catalogue*.

It is described by Sir J. Herschel (*General Catalogue*, p. 56) as very bright, very large, very much extended, very very much brighter in the middle, lenticular, 5′ long. A drawing of it is given in the *Phil. Trans.* for 1833, Pl. XIV. fig. 56; but the nebula is drawn too pointed at the ends, and none of the stars involved in it are shown.

Lord Rosse in the *Phil. Trans.* for 1861, p. 713, Pl. XXV. fig. 5, and *Observations of Nebulæ and Clusters of Stars*, pp. 30, 31, records 13 observations of the nebula between the years 1850 and 1877. He saw 6 stars involved in it, and an oval nucleus; and about 20′ *preceding* the nebula saw a star of 8th or 9th mag. with what appeared to be an atmosphere round it.

The photograph shows the nebula with a distinct stellar nucleus and extensions of faint nebulosity in the *preceding* and *following* directions. On the *south following* side the faint nebulosity is seen to trend southwards, and suggests the idea that the nebula is either circular or an oval seen edgewise, the central star or nucleus being visible through the nebulosity in the direction of the semi-axis minor.

The nebula, as it is drawn by Lord Rosse in the *Phil. Trans.* for 1861, is in fair agreement with the photograph, and he shows five of the seven stars involved in it, and refers to having seen six stars. There is nothing about the 9th-magnitude star 20′ *preceding* the nebula, to which he refers, indicative of an atmosphere, as he suggests, nor does the star present any appearances differing from the other stars. The nebula is surrounded by very rich fields of faint stars, forming curves and festoons, such as are usually seen on all photographs taken with long exposures of the plates to the sky in the proximity of the Milky Way. Apparent *comites* and multiple stars are also numerous.

Admiral Smyth (*Cycle of Celestial Objects*, second edition, p. 67) states that he saw the nebula very distinctly with his instrument as an ellipse, and that it trends (as shown in his sketch, and also in Lord Rosse's sketch and drawing, and in Sir J. Herschel's drawing) in *north following* and *south preceding* directions at a position angle of about sixty degrees; but the photograph shows it to be just on a parallel of declination. It is difficult to reconcile this discrepancy upon the assumption of a change so large in the position angle of the major axis of the nebula within the interval of about eighteen years. On the other hand, it is difficult to realise that the three competent and independent observers named have each made so obvious an error in delineating the position angle.

If Admiral Smyth saw this very faint nebula as an ellipse, it is remarkable that he did not also see the stars involved in it, six of which were seen by Lord Rosse and are shown (seven in number) on the photograph, four of them being much brighter than the nebulosity.

Notes on some Photographs taken with a Visual Telescope.
By H. F. Newall, M.A.

During the past six months several photographs of stars, &c., have been taken with the Newall telescope of the Cambridge Observatory with a view of testing the performance in photographic work of a large telescope constructed for visual work. I beg leave to show to the Society some of the results obtained.

These results may best be set forth if I describe the individual photographs exhibited, explaining at the same time the object aimed at in each attempt. The experiments have been made at considerable intervals, whenever, for some reason or another, spectroscopic work was not possible or convenient. Hence the information has been gathered slowly and under very varied conditions (as to temperature, &c.)

Some details are here given concerning the instrument, since a knowledge of them is necessary to a discussion of the images obtained:

Aperture of the object-glass	24·8 inches	630 mm.
Focal length	29 ft.	8844 mm.

Ratio focal length ÷ aperture = 14·04

The crown and flint lenses are separated only by the thickness of tinfoil.

Details concerning the colour correction of the object-glass:

	Inch.	Millimetre.	
[H_α (C)	− 050	− 1·25 added April 23]	
Minimum between D and *b*	− ·159	− 4·04	Mean of 6 determinations made in course of 2 years with different slit spectroscopes by the Harkness-Vogel method.
H_β (F)	·000	·000	Deduced from photographs of the spectrum of *Polaris* taken with objective prism in front of object-glass; aperture used $10\frac{1}{2}$ inches.
H_γ (G′)	+ ·45	+ 11·4	
H_δ (*h*)	+ 1·07	+ 27·2	
H_ϵ (H_1)	+ 1·50	+ 38·1	
H_ζ (Huggins' α)	+ 2·25	+ 57·2	

Note.—Many slightly discrepant determinations have been made of the chromatic aberration in the red, yellow, and green. The sources of discrepancy are not yet perfectly clear, but there are indubitable signs of a temperature coefficient of considerable importance. The separation of minimum and $H\beta$ foci given above is therefore to be regarded as provisional. In the appearance of star images on warm and cold nights the differences of the colour correction are quite noticeable in careful observation.

To facilitate comparison with other large refractors I append the following table:

Line and Wave-length.	Vienna Telescope. df	$\frac{h}{f}$	$\frac{df}{f}\times 10^5$	Pulkowa Telescope. df	$\frac{h}{f}$	$\frac{df}{f}\times 10^5$	Lick Telescope. df	$\frac{h}{f}$	$\frac{df}{f}\times 10^5$	Newall Telescope. df	$\frac{h}{f}$	$\frac{df}{f}\times 10^5$
	mm.			mm.			mm.			mm.		
H_α (C) 656	2·7	·000017	26	3·0	·0000115	21	5·3	·0000162	31	3·1	·0000250	35
D 589	0·0	·000	0	0·0	·000	0	0·0	·000	0	0·0	·000	0
H_β (F) 486	6·0	·0000378	58	6·4	·0000245	45	11·4	·0000349	66	4·0	·0000323	45
H_γ (G′)434	23·5	·0001478	227	32·9	·0001258	233	48·3	·0001471	281	15·4	·0001243	174
H_δ (h) 410	...	...	...	...	...	...	81·5	·0002484	474	31·2	·0002518	353

Aperture	27 in. 675 mm.	30 in. 762 mm.	36 in. 914 mm.	24·8 in. 630 mm.
Focal length	34 ft. 10,360 mm.	46 ft. 14,120 mm.	56½ ft. (?) 17,200 mm.	29 ft. 8,844 mm.
Ratio $\frac{\text{F. L.}}{\text{Ap.}}$	15·3 : 1	18·5 : 1	19·1 : 1	14·0 : 1
Glass cast by	Feil	Feil	Feil	Chance
Glass worked by	Grubb	Clark	Clark	Cooke
Date	1881	1883	1886	1868

[*Note added April 23.*—The numbers given for the Newall telescope are based, so far as the visual part of the spectrum is concerned, on determinations made under very favourable conditions on April 21. The temperature in the dome at the time was 38° F. (3°·3 C).]

Plate No. 1.—For a study of the chromatic aberration of the object-glass in the region of the foci for violet and ultra violet light.

1894 March 29. 8.33–10.11. Spectrum of *Polaris.*

Plate: Edwards's instantaneous isochromatic.

South Kensington objective prism, 10½ inches aperture, mounted in front of the central part of the object-glass of the equatorial.

Nine exposures, 10 minutes each, with change of focus between successive exposures by first three equal movements of $\frac{3}{16}$ inch from visual focus, and lastly five equal movements of $\frac{2}{8}$ inch up to 2¼ inches from visual focus.

The driving clock of the equatorial was so rated that the spectrum did not trail on the plate, as in the usual method adopted in photographing spectra with an objective prism. Thus the width of the spectrum in that region which was in focus on the plate was very small. The width in the narrowest part near H_δ (*h*) at focus +1 inch was found by measurement to be 2″·14 (0·092 mm.).

The plate shows very clearly the travelling of the focussed part of the spectrum from the yellow to the violet end of the spectrum, as the plate is drawn out further and further. The method gives good reliable results between H_β (F) and the ultra violet, but not in the green and yellow. The line H_β (F) forms, however, an excellent connecting link between determinations made in the method above described and the usual spectroscopic method due to Harkness and employed by Vogel and others.

From this plate the results given in an earlier paragraph were deduced.

Plate No. 2.—For a study of the spherical aberration of the object-glass.

1894 March 29. 12.10–12.45. *Polaris.*

Plate: Edwards's instantaneous isochromatic.

Screen: Dark yellow glass.

Nine exposures: three for central circular aperture, 6 inches in diameter, for 2 minutes each—one at the visual focus, the other two at $+\frac{3}{16}$ inch and at $-\frac{3}{16}$ inch; three for exterior annulus, with external radius 12 inches, and with internal radius 11½ inches, for 2 minutes each, with same focussing as in the first case; three more with the same annulus and focussing, but with 3 minutes' exposure.

The images are very satisfactory in both cases, and careful comparison shows that the images at that focus which was called "visual," and which was determined with 24 inches aperture,

are distinctly better than the images obtained either $\frac{3}{16}$ inch inside or $\frac{3}{16}$ inch outside that focus.

Though the areas of the central and annular apertures are in the ratio of 9 to 12, still the plate shows that while an exposure of 2 minutes is enough for the central aperture, an exposure of 3 minutes is hardly enough to give comparable images with the (larger) annular aperture.

Inspection of the images with an eye-piece makes clear the need for the longer exposure when the annulus is used. The effect of atmospheric tremor is to give rise to rays round the central image. The rays are in constant movement round the centre, sometimes long (10″), sometimes short (2″); they are therefore not the result of defect in the glass, but are due to a momentary annulling of the contribution of disturbance which should come from some part of the annulus, but which, from those atmospheric causes that give rise to "bad seeing," is suppressed, leading to an upset of that balance necessary by the principles of the undulatory theory of light to the formation of a perfect image. In consequence of these moving rays, the light which in perfect conditions of seeing would be concentrated within a very small area is generally spread over different parts of an area having a diameter of 20″ or 30″, and is only for a moment now and then collected into a circular disc without the constantly moving rays.

Plate No. 3.—For a study of the effect of change of focus on the size and appearance of the photographic image of a bright star.

1894 January 18. 10.30–10.50. *Procyon.* (Mag. Oxon. Uranom. 0·5)

Plate: Wratten and Wainwright, "drop shutter."

No screen.

Thirteen exposures, thirty seconds each, with change of focus betwen successive exposures, by equal movements of $\frac{3}{16}$ inch from visual focus to a focus $2\frac{1}{4}$ inches outside the visual focus.

Focus.	Appearance of Image.
"Visual"	Blurred image about 100″ diameter, with ragged edge; increasing density to the centre; no defined nucleus.
(50) + $\frac{3}{16}$ inch	Smaller diameter, but similar to last.
(100) + $\frac{3}{8}$ „	„ „ distinct nucleus now appears.
(150) + $\frac{9}{16}$ „	Similar to last; smaller diameter.
(200) + $\frac{3}{4}$ „	„ „ diameter about 60″.
(250) + $\frac{15}{16}$ „	Smaller diameter; small disc within the ragged edge; defined nucleus.
(300) + 1 $\frac{1}{8}$ „	Ragged edge disappearing; disc increasing; nucleus still defined.
(350) + 1$\frac{5}{16}$ „	No ragged edge; disc, 43″·8 in diameter; defined nucleus. Smallest image.

From this point onwards the appearance does not change; the diameter steadily increases; edge, comparatively speaking, clean cut; nucleus quite definite. Diameter at $2\frac{1}{4}$ inches about 100″.

The plate also has on it images of Bird's double (0″·8), which is equivalent to a star of about the 8th magnitude. The appearance of the image hardly changes at all. It may be described as a small nucleus with ragged edge about 8″ or 10″ in diameter. The most intense nucleus is that at focus $+1\frac{1}{8}$ or $+1\frac{5}{16}$ inch.

Further, a small image of an 11th magnitude star is seen on the plate.

From the chromatic aberration curve deduced from the photographs of the spectrum of *Polaris* it appears that the best image on the plate now under consideration is that formed when the plate is placed at the focus for H_δ (h); a result which falls in completely with expectation based on a knowledge of the curve of sensitiveness of the photographic plates used, and the distribution of the foci for different wave-lengths along the axis of the equatorial.

The undulatory theory demands that with a perfectly figured object-glass the intensity of light at the centre of the diffraction pattern should be proportional to the fourth power of the aperture. Whilst it is improbable that practically this can be fulfilled, still it appears that the existence of the nucleus in the image is connected with this concentration of light in the focussed image amidst the superposed circles of aberration of the light coming from foci behind and before the plate.

Plate No. 4.—For a study of the applicability of dry collodion plate.

1894 February 3. 13 10–13.55. *Procyon.*

Plate: Hill Norris. Dry collodion, yellow label.

No screen.

Full aperture.

Twenty-five exposures: five exposures, $\frac{1}{4}^m$, $\frac{1}{2}^m$, 1^m, 2^m, and 4^m at each of the following focussings: visual, $+1\frac{3}{16}$ inch, $+\frac{3}{8}$ inch, $+1\frac{9}{16}$ inch, $+\frac{3}{4}$ inch.

Good small images about 5″–10″ diameter are got of the bright star (mag. 0·5); but the image of an 8th magnitude star only begins to be visible on the plate after 4 minutes' exposure. The best image is got with focus $+\frac{3}{8}$ inch, that is, at the focus of light with wave-length intermediate between H_β (F) and $H\gamma$.

Plate No. 5.—For a study of the appearance of star images on an isochromatic plate, a light yellow screen being used; also for a study of the change of appearance of such images with varied exposures.

1894 January 23. 9.49–10.43. *Procyon* (mag. 0·5).

Plate: Edwards's instantaneous isochromatic.

Screen: Light yellow screen.

Aperture: full, 25 inches.

Twenty-five exposures: five at visual focus with the following exposures: $\frac{1}{4}^m$, $\frac{1}{2}^m$, 1^m, 2^m, 4^m; five similar exposures at

each of the following focussings: $+\frac{3}{8}$ inch, $+\frac{3}{4}$ inch, $+1\frac{1}{8}$ inch, $+1\frac{1}{2}$ inch.

The most definite "discs" are got at the focus $+\frac{3}{4}$ inch. There is no ragged edge; the disc does not increase much in size with lengthened exposure. The following measures were made of the discs of *Procyon* at focus $+\frac{3}{4}$ inch:

Exposure	$\frac{1}{4}^m$	$\frac{1}{2}^m$	1^m	2^m	4^m
Diameter	33″·32	34″·02	34″·25	34″·48	35″·65

Probably the best focus for a photograph intended for measure of images of neighbouring bright and faint stars would be $+\frac{3}{8}$ inch. An 8th magnitude star shows well with an exposure of $\frac{1}{4}^m$; the diameter of the image is about 3″, and though the edge is not very definite, bisection with a micrometer wire would be easy. In none of the twenty-five exposures does the image of the 8th magnitude star exceed 5″ in diameter. The images at visual focus are the best. But, as has been stated above, for measures of bright *and* faint stars the images at focus $+\frac{3}{8}$ inch would probably prove best.

Plate No. 6.—For a study of the effects of diminishing the circles of aberration by cutting down aperture; and for a trial of medium sensitiveness in isochromatic plates.

1894 April 4. 11.10–12.24. *β Geminorum* (mag. 1.36).

Plate: Edwards's medium isochromatic.

Screen: Light yellow glass.

Twenty-four exposures: five exposures with 24-inch aperture, $\frac{1}{4}^m$, $\frac{1}{2}^m$, 1^m, 2^m, and 4^m, at each of the following focussings: $\frac{3}{16}$ inch, visual, $+\frac{3}{16}$ inch; five exposures with 12-inch aperture durations as above, all at $+\frac{3}{16}$ inch focus; four exposures with 12-inch aperture, durations 1^m, 2^m, 4^m, 8^m, all at visual focus.

The images obtained with the smaller aperture are excellently good discs, but so small for so bright a star as *β Geminorum* (Mag. Oxon. Uranom., 1·36) as to make one fear that long exposures would be needed for fainter stars.

Plate No. 7.

1894 March 23. 11.35–11.45. *Castor.*

Plate: Edwards's instantaneous isochromatic.

Screen: Dark yellow glass.

Plate set at the visual focus behind a Thornton-Pickard spring shutter.

Twelve exposures: longest 8 seconds, shortest 2 seconds.

The images of the two components are in all cases distinctly separated, and are easily measurable discs of small dimensions. The seeing at the time the plate was exposed was fair. The position angle is, even in casual inspection, obviously different in the different exposures; a fact which must be attributed to atmospheric tremor. No measures of the position angle

have been made, but the following results of measurement of the separation of the centres are of interest. Five bisections of each component in each pair were made.

Exposure.	6 sec.	4 sec.	2 sec.	4 sec.	6 sec.	8 sec.
Distance	5″·71	5″·75	6″·01	5″·66	5″·78	5″·52
Probable error	±0·0061	±0·0103	±0·0063	±0·0065	±0·0097	±0·0082
Character of image	good round disc	good round disc	small star, faint, but easily seen	elongated discs	bad shape; triangular	round with small excrescence on one side

Diameters of star images in the exposure of 8 seconds:

Large star (single reading of each edge)	4″·03
Small star „ „ „	2·56
Separation of nearest edges	2·51
Deduced separation of centres	5·805

There is evidence of diminution of measured separation with increased exposure. Such diminution is what one would expect from the fact that each component falls on a part of the plate already illuminated by the other component, with the result that the image of each component grows more rapidly on the side near to the other component than on that remote from it. In bisecting the images with the micrometer, a false centre is taken.

The effects of the chromatic aberration of such a telescope as the 25-inch equatorial at Cambridge make themselves felt very markedly in spectroscopic work in a way that hardly needs explanation. If the slit of a spectroscope, put on at the eye-end, is adjusted to be in the focus for H_β light, the circle of aberration on the slit for H_ϵ light is so considerable that but a very small percentage of H_ϵ light gets into the spectroscope. To obviate this difficulty in a way that would in other ways be advantageous, I have had a simple lens made, which, being set in the cone of rays converging from the object-glass of the equatorial to the focus at about 5 feet from that focus, should, by being chromatically uncorrected, just correct the over-corrected object-glass. In this way the separation of the H_β and H_ϵ foci is reduced from 1·5 inches to about two-tenths of an inch, and, but for some mistake made in the working of the lens, the correction would have been more satisfactory even than it is, and I hope shortly to have the more perfect correction made.

The focal length of the combination is shorter by about 18 inches than that of the object-glass alone. It is necessary, therefore, to arrange that the collimator of the spectroscope is

pushed up into the equatorial tube, and space is thus economised and strength gained; and the alteration of ratio of focal length to aperture is one which only brings convenience with it. The correction thus obtained gives very satisfactory results in spectroscopic work.

In having the lens made I intended also to see whether the resulting image could be enlarged by an enlarging camera attached to the equatorial, and had hoped that satisfactory enlargements of planets might thus be obtained, inasmuch as in such work the field is small.

I have made several attempts to photograph *Jupiter*, and have hitherto got results that do not satisfy me. The failure I attribute in part to the difficulty of the subject—the detail is very fine—in part to unfavourable atmospheric conditions, and in part to the imperfection of the correcting lens. I have pleasure in exhibiting to the Society a slide showing the sort of result obtained. In order to test the performance of the enlargement apparatus on other objects, and for the sake of being able more easily to focus the camera, I have taken some enlargements of lunar craters with the same arrangement. Of these also I exhibit slides. The plates on which the originals were taken are Edwards's instantaneous isochromatic; a light yellow glass was used as screen, and the enlargement of the corrected image is sixfold.

The Star Cluster 3315 (*Cape Observations*).

By H. C. Russell, B.A., F.R.S.

The remarkable discovery by MM. Henry of a nebulous background to the *Pleiades* induced me to experiment with the same object in view on the finest of our southern star clusters, which Herschel describes as "the most brilliant object of the kind I have ever seen"; "a glorious cluster of immense magnitude, being at least two fields each way"; and in another place (two or three fields each way), "the stars are 8, 9, 10, and 11 magnitudes, but chiefly of the tenth, of which there must be at least 200."

Three photographs have been taken with a view of finding out if there existed any nebulous light amongst the stars of this magnificent cluster. The first was taken on 1893 April 11, and was exposed in the star camera $7\frac{1}{2}$ hours. On it there is not the slightest sign of any nebulous background, although the plate has recorded in the square degree in which the cluster stands no fewer than 12,702 stars. The second was taken on April 12, and was exposed for $6\frac{3}{4}$ hours. The night was better than that of the 11th, and as a consequence the plate shows 14,551 stars in the same square degree, and on this also there is

no sign of nebulous background. The third was taken April 23, and it was exposed for $6^h\ 35^m$, and this also is altogether without nebulous background, although it shows 10,946 stars in the same square degree.*

The photographic plates used were extremely sensitive, so much so that seven hours' exposure on them would be equivalent to at least ten hours on the plates in use two years since. I think, therefore, that we may assume that there is no nebulous background to the star cluster H 3315 at all approaching that in the *Pleiades* in brilliance. This cluster appears to the unaided eye as a conspicuous white spot following the nebula about *η Argûs*, and it covers a space about equal to one square degree. It is in R.A. $11^h\ 2^m$, Decl. 58° 9′ S. The *réseau* lines on the photograph enclose spaces 5 minutes of arc each way.

[Slide 10 shows this cluster as photographed here with the star camera, and slide 9 its relation in position to *η Argûs*. If No. 9 numbered corner be held as upper right-hand corner the top is north and the left the following side, and the cluster follows the nebula about one inch, and a little north.]

1894 *February* 2.

A Seconds Contact-Maker for Astronomical Clocks.

By H. C. Russell, B.A., F.R.S.

The difficulty in getting good seconds contacts from astronomical clocks, owing to irregularities due to errors in the spacing of the escape wheel and the faulty methods of contact used, has induced me on several occasions to try and get some attachment to the pendulum that would do the work. Invariably I have been unsuccessful in the search for a good working device, until in July last it occurred to me that if a wheel were attached to the pendulum rod it might be made to roll over a spring and press it down to contact without *any friction except that on the* axis of the wheel. The idea looked promising, and I had one made, which after several months' trial is good enough to publish, since it is likely to be useful to others.

The design is so simple that with the diagram herewith (Plate 7) little explanation is required.

First it will be seen that the contact is made through the medium of a very light wheel attached to the pendulum, which

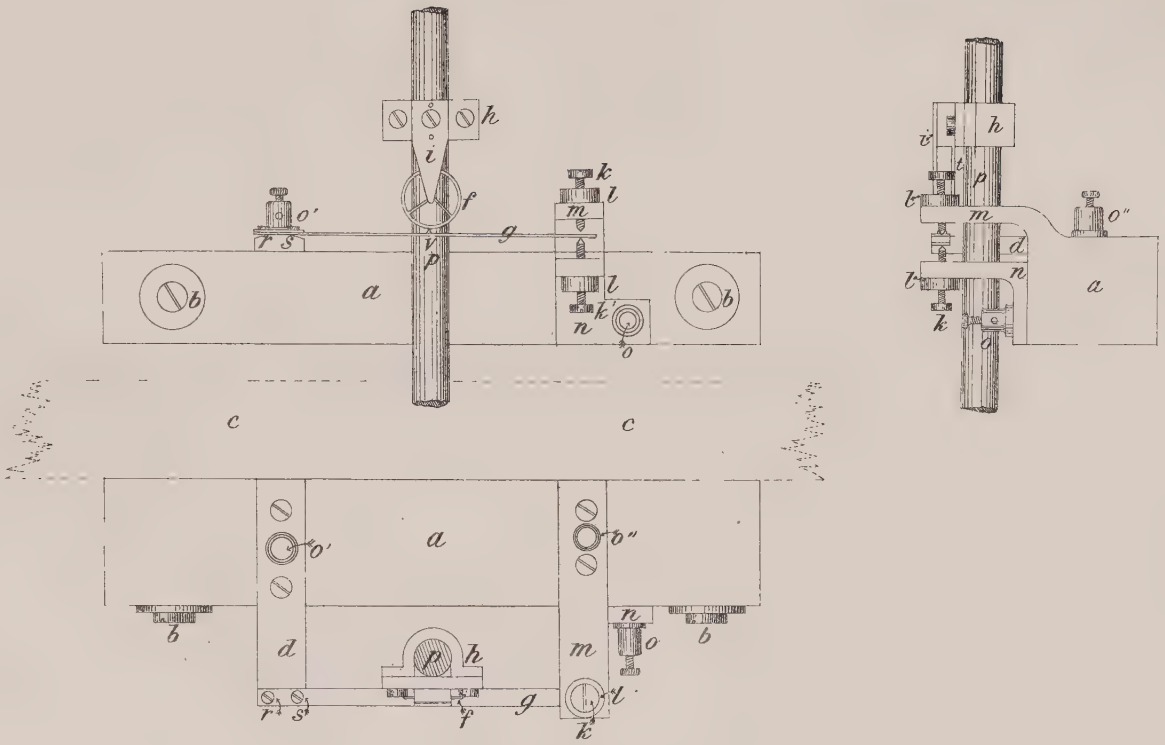
* It may be mentioned that a count of the stars in the same space (1°) in the negative taken with the portrait camera (slide No. 9) of this object, and exposed for eight hours, shows 1,355, or only one-tenth of the number shown on the negative taken with the star camera on 1893 April 12.

at each swing rolls over a little bridge on the spring and depresses it to make contact. This wheel is the plain balance wheel taken out of a watch, and it therefore has pivots in which friction has been reduced to a minimum. It is also obvious from the arrangement of these parts that after the pendulum passes the centre the recoil of the spring by pressing against the retreating wheel gives a slight impulse to the pendulum, and so restores a part of the work done in depressing it.

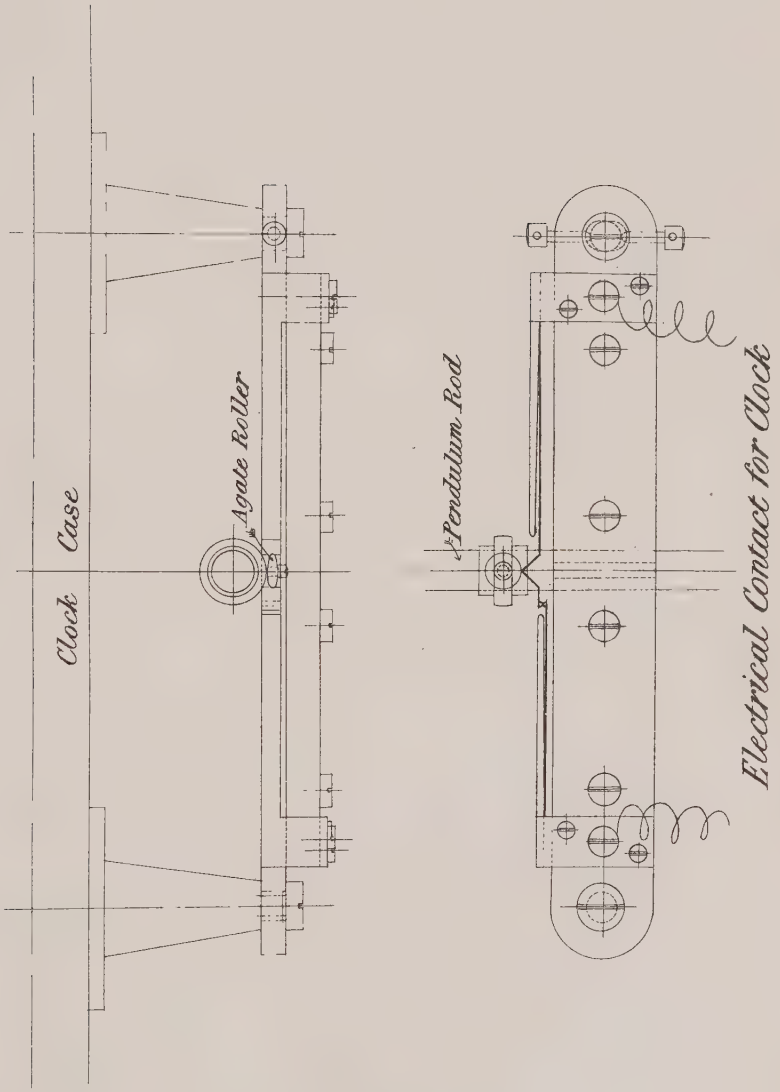
The question of importance is, How much does such a contact reduce the arc of the pendulum? The minimum effect I have not yet determined, but I have found that the maximum effect—which is produced by using a current of six volts, or strong enough to occasionally fuse the platinums together, unless a considerable tension is put on the contact spring—does not reduce the arc of the pendulum any more than the old tilt-hammer contact did when working at its best. Such a current is, of course, quite unnecessary, and by reducing it the strength of the contact spring may be proportionately reduced, and with it the work the pendulum has to do, and the demand therefore made on the clock is far less than that required to work either the tilt-hammer contact or that in which two springs are pressed together by the clock escape-wheel, or another wheel on the same axis.

It is a convenience to have the contact-maker placed where it can be seen and cleaned, and especially such an arrangement as this, which can be used either as a make or a break circuit; for to make it a break circuit all that is necessary is to move the wire from one binding screw o to the other o''.

Turning now to the diagram, the attachment on the pendulum rod h is placed about fourteen inches above the top of the pendulum bob—it may be anywhere, but this is the most convenient place—i and t carry the (balance) wheel f; the other parts are attached to a piece of hard wood $a\ a\ a$, which in turn is screwed on to the back of the clock case $c\ c$ by the screws $b\ b$. The bracket piece d is screwed on to a, and carries a binding screw o' and the spring g, which is attached to it by the screws r and s. Under these screws the spring is made thicker, so that it can be screwed in different positions on the rounded base on which it rests, and so adjust the tension of the spring g. Between the steel bar v on g and the screw s, g is filed away as much as possible, to make it easily bent down for contact. At the point where g rests upon k and k' it is coated with platinum, and both screws are tipped with the same metal. The bracket m carries the upper contact screw k and the binding screw o'', while n carries the lower contact screw k' and the binding screw o; $l\ l$ are locking nuts to keep $k\ k'$ in their places; p is the pendulum rod, shown at rest. The attachment h on the pendulum was made much lighter than it is shown in the diagram; the same remark applies to the spring g, which is made of bronze, 0·008 inch



Seconds Contact-maker for Clocks.



Electrical Contact for Clock

thick. In other respects the diagram shows the several parts of the size they were actually made.

Observatory, Sydney:
1893 *December* 20.

P.S.—The necessary break in the circuit to leave out the 60th second is made by a wheel on the escape-wheel axis, which has only one tooth, and this tooth lifts a small tilt-hammer arrangement once a minute and breaks circuit for one second.

[*Note by the Editors.*—When the above paper was read to the meeting on 1894 March 9, it was remarked that similar devices had been used before. Messrs. T. Cooke & Sons, of York, have shown in a sketch (Plate 8) an arrangement of the kind made by them some years back. As it does not appear certain, however, that any account of such an arrangement has yet been published, the Council deemed it advisable to publish Mr. Russell's paper, together with Messrs. Cooke's sketch.]

Occultation of α Virginis observed at Dunsink, 1894 March 22.
By Professor Arthur A. Rambaut, M.A., Sc.D.

The occultation of *α Virginis*, which took place on the morning of Good Friday, was observed here by my assistant, Mr. Lyster, and myself. I used the 12-inch refractor, with a power of 300, and recorded the times of disappearance and reappearance electrically on the chronograph. Mr. Lyster was stationed at the 5-inch guiding telescope, attached to the "Roberts" photographic equatorial, carrying a power of 100, and noted the times by direct comparison with an Arnold clock in the dome. The error and rate of this clock were determined by comparing it with a chronometer which was also compared with the Dent sidereal clock.

At the time of disappearance we were enveloped in a dense fog, which completely obscured *Spica* and *Saturn* (which was in the neighbourhood) from the naked eye, but by the time the star was due to reappear the fog had almost entirely cleared away.

To me the star seemed to disappear instantaneously at $15^h\ 31^m\ 46^s{\cdot}97$ local sidereal time. This was, of course, at the bright limb.

At emergence I put a note to the effect that "reappearance was not quite instantaneous, perhaps a tenth of a second before full brilliance was attained." The time noted as that of reappearance corresponds to the first gleam of light sufficient to attract my attention. This occurred at $16^h\ 41^m\ 24^s{\cdot}91$ local sidereal time.

Mr. Lyster reports that both disappearance and reappearance seemed to him to occur instantaneously; the former at $15^h\ 31^m\ 45^s{\cdot}9$, and the latter at $16^h\ 41^m\ 24^s{\cdot}6\pm$, local sidereal time.

Dunsink Observatory, Co. Dublin:
1894 *March* 27.

Observations of Denning's Comet (a 1894), made at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

The observations were made with the East, or Sheepshanks, equatorial, aperture 6·7 inches, by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power 55.

Greenwich Mean Solar Time.					Observer.	✱−✱ R.A.	Corr. for Refraction.	Log Factor of Parallax.	−✱ N.P.D.	Corr. for Refraction.	Log Factor of Parallax.	No. of Comps.	Appt. R.A.	Appt. N.P.D.	Comp. ✱
1894.	d	h	m	s		m s	s		′ ″	″			h m s	° ′ ″	
Mar.	27	8	20	46	A. C.	−1 20·49	0·00	9·1467	−6 4·9	0·0	0·4945	3	9 58 12·56	58 17 48·2	*a*
	27	8	28	20	,,	−1 52·58	0·00	9·1040	+2 44·9	0·0	0·4905	6	9 58 13·32	58 17 54·4	*b*
	31	8	50	35	,,	−2 12·85	0·00	8·9045	−1 39·5	0·0	0·5229	7	10 12 28·29	60 29 49·1	*c*
Apr.	2	8	43	52	,,	−2 22·02	0·00	8·9413	−0 59·5	0·0	0·5439	6	10 19 0·72	61 34 20·2	*d*
	2	8	40	1	,,	−5 5·00	0·00	8·9792	−3 38·3	0·0	0·5449	5	10 19 0·35	61 34 15·6	*e*
	3	10	16	24	L.	+0 52·55	0·00	8·8874	+4 43·1	0·0	0·5511	2	...	...	*f*
	3	10	16	24	,,	+0 19·24	0·00	8·8874	−6 22·8	0·0	0·5511	2	10 22 22·47	62 8 25·7	*g*
	6	8	42	27	A. C.	−2 3·06	0·00	8·9211	+0 3·4	0·0	0·5780	5	10 31 8·49	63 40 57·6	*h*
	9	10	40	34	,,	−1 18·00	0·00	9·1063	−1 4·2	0·0	0·6092	4	10 39 43·75	65 16 1·5	*i*
	9	10	40	34	,,	−1 18·72	0·00	9·1063	−1 43·7	0·0	0·6092	4	10 39 43·89	65 16 2·1	*k*

Notes.

The observations are corrected for refraction, but not for parallax. They are also corrected for the errors of inclination of the wires, and for the motion of the comet.

On April 2 a slight haze and the close proximity of the 9·5 magnitude star B.D.+28° 1877 to the comet made observation of the latter very difficult. The apparent place of the star on April 2 was R.A. $10^h\ 18^m\ 59^s{\cdot}35$, N.P.D. 61° 35′ 21″·9 (authority, *Bonn Observations*, vol. vi.), and it was estimated that the comet was in conjunction with it in R.A. at $8^h\ 31^m$ G.M.T.

On April 6 the night was hazy and the comet never well defined.

The initials L. and A.C. are those of Mr. Lewis and Mr. Crommelin respectively.

Comparison Stars.

	Star's Name.	R.A., 1894 o.	N.P.D., 1894.o.	Authority.
		h m s	° ′ ″	
a	W.B. (2) IX., 1211	9 59 30·95	58 23 54·1	Leiden Ast. Gesell. Zones, 163, 278, and Pulkova Catalogue, 1875.
b	W.B. (2) IX., 1234, 1235	10 0 3·80	58 15 10·5	Leiden Ast. Gesell. Zones, 41, 286.
c	W.B. (2) X., 246	10 14 39·07	60 31 28·4	Paris Catalogue, 1860 and 1875.
d	B.D. + 28°, 1879	10 21 20·69	61 35 19·0	Bonn Observations, vol. vi.
e	W.B. (2) X., 439	10 24 3·29	61 37 52·9	Weisse's Bessel (2) and Lalande.
f	B.D. + 28°, 1882	10 21 29	62 5	Bonn Observations, vol. iv.
g	W.B. (2) X., 386	10 22 1·20	62 14 47·7	Weisse's Bessel (2).
h	W.B. (2) X., 619, 620	10 33 9·54	63 40 52·5	Paris Catalogue, 1875.
i	B.D. + 24°, 2269, 1st *	10 40 59·77	65 17 3·4	Berlin Ast. Gesell. Zones, 217, 225, 236.
k	„ 2nd *	10 41 0·63	65 17 43·5	Berlin Ast. Gesell. Zones, 236, 245, 249.

Note.—*a* is the double star Σ 1406; the mean of the places for the components has been used.

Observations of Comet a 1894 (*Denning*). By William E. Plummer.

The following observations of Denning's Comet have all been made by the method of transits over a pair of wires, inclined at an angle of 45° to the meridian, the comet not being sufficiently bright to permit the use of a filar micrometer on the equatorial of the Liverpool Observatory. In the column "Observer" the letters P. and S. refer to Mr. Plummer and Mr. Skinner respectively.

Greenwich Mean Time of Observation.				☄−✶ R.A.		Apparent R.A. of ☄.			☄−✶ Declination.			Apparent Declination of Comet.			No. of Transits.	Observer.	Log. Fact. of Parallax a	Log. Fact. of Parallax δ	Star of Comp.
	h	m	s	m	s	h	m	s	′	″		°	′	″					
Mar. 27	10	2	49·8	−1	37·60	9	58	28·37	− 4	46·50		+31	40	4·9	10	P.	8·3539	0·5059	*a*
	10	14	20·7	−1	3·55	9	58	29·55	+ 3	48·8		+31	39	45·7	10	P.	8·6563	0·5077	*b*
	10	55	0·5	−1	0·48	9	58	32·62	+ 3	23·5		+31	39	20·4	5	S.	8·9258	0·5133	*b*
28	9	39	45·8	+1	54·22	10	2	6·10	− 7	47·0		+31	7	34·3	10	P.	8·2291*n*	0·5161	*c*
	9	39	45·8	−	23·08	10	2	6·40	+ 0	26·9		+31	7	24·3	10	P.	8·2291*n*	0·5161	*d*
	9	55	52·4	−	20·62	10	2	8·86	+	14·5		+31	7	11·9	8	S.	8·0863	0·5162	*d*
29	9	7	49·9	−	6·72	10	5	36·29		...			...		9	P.	8·8648*n*	...	*e*
	9	4	3·6		...		...		− 4	44·0		+30	35	33·0	8	P.	...	0·5320	*e*
	9	24	14·4	−	3·09	10	5	39·02	− 5	14·1		+30	35	2·9	6	S.	8·6436*n*	0·5300	*e*
Mar. 30	9	15	14·3	−1	8·48	10	9	7·00	+12	10·0		+30	2	29·9	10	P.	8·7696*n*	0·5389	*f*
	9	23	19·5	−1	59·88	10	9	8·32	− 2	40·7		+30	2	16·5	10	P.	8·6479*n*	0·5376	*g*
	9	44	14·0	−1	4·30	10	9	11·18	+11	27·7		+30	1	47·6	6	S.	7·8491*n*	0·5355	*f*
Apr. 1	8	1	4·0	+	48·48	10	15	40·96	− 4	6·8		+28	58	58·7	10	P.	9·2653*n*	0·5856	*h*
	8	1	4·0	+	8·90	10	15	40·79	− 5	15·2		+28	59	0·2	10	P.	9·2653*n*	0·5856	*i*

March 27.—The comet ill defined and the observation not thought very exact.
March 28.—The comet seen much better; a definite point seen in the comet to which the observations refer.
March 29.—An observation of declination rejected from discordance.
March 30.—The observation difficult, owing to very brilliant aurora. The sky was not dark.

Mean Places of Stars of Comparison.

Star's De ignation or Authority.	Mean Red. 1894.0	Corr. to Apparent Equinox.	Mean Declination 1894.0.	Corr. to Apparent Equinox.	Letter of Reference.
	h m s	s	° ′ ″	″	
Leiden Zones, 41, No. 37	10 0 3·87	+2·10	+31 44 50·4	+1·0	*a*
„ „ 163, No. 126	9 59 31·01	+2·09	+31 35 55·9	+1·0	*b*
„ „ 163, No. 127	10 0 9·82	+2·06	+31 15 20·4	+0·9	*c*
„ „ 172, No. 25	10 2 27·40	+2·08	+31 6 56·6	+0·8	*d*
Washington Zones, No. 4328 Leiden Zones, 39, No. 60	10 5 40·93	+2·08	+30 40 16·5	+0·5	*e*
Greenwich 1864 Cat. No. 1243 Glasgow Cat. No. 2658	10 10 13·42	+2·06	+29 50 19·8	+0·1	*f*
Leiden Zones, 41, No. 46	10 11 6·13	+2·07	+30 4 57·1	+0·1	*g*
Bonn Zones, +29°, No. 2032	10 14 50·43	+2·05	+29 3 5·8	−0·3	*h*
Paris Catalogue, No. 12665	10 15 29·84	+2·05	+29 4 13·7	−0·3	*i*

Liverpool Observatory:
1894 *April* 12.

Note on the Computation of the Brightness of the Planets, with some Ephemerides for Observations of the Brightness of Mercury. By A. Marth.

In the *Nautical Almanacs* for the years 1835 to 1857 the times of the greatest brilliancy of *Venus* are predicted to the minute. Wondering at this precision in the prediction of such an occurrence, I tried, by computing a number of instances, to find out what hypothesis could have been adopted in the computations. The predicted times were found to be within a couple of days of the times computed upon the ordinary assumption that the diminution of brightness due to the defect of illumination depends simply on the proportion of the unilluminated portion to the whole of the disc; but what modification of this assumption had been introduced, or how the apparent precision had been obtained, I failed to detect. When, in 1853, I got the opportunity of making inquiries at the *Nautical Almanac* office, I learnt that nothing was known there about any hypothesis, but that the predicted times were very easily computed to a minute, as they were merely the times when the distance of *Venus* from the Earth reached a certain value. As this value had obviously been deduced upon the ordinary assumption, but by neglecting the eccentricities of the orbits, I pointed out the illusory character of the predicted times, and recommended to give in future merely the day, but the right day. Since the distances of *Venus* from the Sun and from the Earth r and Δ and the distance of the Sun from the Earth were given in the *N. A.*, the light-ratio of *Venus* could be found from them, without actually computing the phase angle v or the angle at *Venus* between r and Δ. For, assuming that the Sun lights up just one-half of the surface of the planet, or disregarding the small zone of doubtful breadth beyond, the light-ratio would be

$$\frac{\cos^2 \frac{1}{2} v}{r^2\Delta^2}, \text{ or } \frac{(r+\Delta)^2-R^2}{r^3\Delta^3};$$

so that by computing this value, or, if preferred,

$$\frac{(r+\Delta+R)\,(r+\Delta-R)}{r^3\Delta^3},$$

for some days near the time, the day during which this value reached a maximum would be the right one. This recommendation was adopted in the *N. A.* for 1858, and the computations have been made since in this manner; but from 1875 onwards the hour of the greatest brilliancy has again been inserted.

The logarithm of the light-ratio (0·4 of which represents

a difference in brightness of one star-magnitude), according to the foregoing formula, the phase angle v, the angle e at the Earth between R and Δ, and the brightness of the planet according to Professor G. Müller's empirical formula for some days about the times of this year's maxima are the following, the magnitudes for the days in January having been already given by Müller himself in his paper "Ueber den grössten Glanz der Venus," *Astron. Nachr.*, vol. 132, p. 300:—

Greenwich Noon. 1894.	$\log. \frac{(r+\Delta)^2-R^2}{r^2\Delta^2}$	v	e	Müller's Mag.
		°	°	m
Jan. 9	1·07861	115·75	41·24	−4·3776
10	·07942	116·81	40·78	−4·3798
11	·07973	117·89	40·29	−4·3809
12	·07949	118·99	39·78	−4·3809
13	·07864	120·12	39·24	−4·3802
14	1·07714	121·28	38·68	−4·3782
Mar. 21	1·04501	120·92	38·40	−4·297
22	·04565	119·79	38·93	−4·297
23	·04570	118·68	39·43	−4·296
24	1·04519	117·60	39·90	−4·294

The interesting results which Professor Müller has deduced from his own measurements of the brightness of *Mercury* (in vol. viii. of the *Publicationen des Astrophysikalischen Observatoriums zu Potsdam*, and in his paper "Ueber die Lichtstärke des Planeten Mercur," in the *Astron. Nachr.* vol. 133, p. 47 ff.) render it very desirable that these results should be tested and the measurements, if possible, extended over a greater range of the phase angle. The smallest angular distance of *Mercury* from the Sun, at which Müller has succeeded in getting some measures, is 14°·7 (on February 14, 1881, in zenith distance 85°·1, the comparison being made with *Venus*), so that it will be feasible to extend the range, even if the difficulties in getting good measures nearer to the Sun cannot be surmounted. This may be seen by looking over the following ephemerides, which give the phase angle v, the angle e at the Earth between *Mercury* and the Sun, and the brightness of *Mercury* expressed in star magnitudes and computed (I.) by Müller's (second) empirical formula, and (II.) upon the makeshift assumption that the alteration of magnitude due to the defect of illumination is just double of what it should be according to the usual assumption, or, what amounts to the same, that the light-ratio is

$$\frac{\cos^4 \frac{1}{2}v}{r^2\Delta^2} \quad \text{instead of} \quad \frac{\cos^2 \frac{1}{2}v}{r^2\Delta^2}.$$

There is no justification for this makeshift assumption except the empirical one that, within the range of the phase angle between

50° or 60° and 120°, it gives no greater discrepancies from the measured magnitudes than Müller's own formula, while outside this range the resulting magnitudes diverge rapidly, so that their comparison indicates sufficiently that for the recognition of the true hypothesis measurements over a considerably extended range are required. For the sake of the comparison the magnitudes derived from

$$\text{I.} = 5 \log\left(\frac{r\Delta}{r_0}\right) - 0{\cdot}901 + 0{\cdot}02838\,(v-50°) + 0{\cdot}0001223\,(v-50°)^2,$$

wherein $\log \frac{1}{r_0} = 0{\cdot}41218$

are carried some 10° beyond the limits of the phase angle within which they are valid. The magnitudes given by II. are

$$\text{II.} = 5 \log\left(\frac{r\Delta}{r_0}\right) - 1{\cdot}25 + 10 \log \sec \tfrac{1}{2}v.$$

The angles v and e are conveniently computed in the following way:—

In the plane triangle formed by $r\Delta\mathrm{R}$, in which the angle v is opposite to R, and e opposite to r, we have

$$\cos v = \frac{r^2+\Delta^2-\mathrm{R}^2}{2r\Delta} \text{ and } \cos e = \frac{\mathrm{R}^2+\Delta^2-r^2}{2\mathrm{R}\Delta}.$$

Hence
$$\tan^2 \tfrac{1}{2}v = \frac{1-\cos v}{1+\cos v} = \frac{\mathrm{R}+r-\Delta}{\mathrm{R}+r+\Delta} \cdot \frac{\Delta+\mathrm{R}-r}{\Delta-(\mathrm{R}-r)};$$

$$\tan^2 \tfrac{1}{2}e = \frac{1-\cos e}{1+\cos e} = \frac{\mathrm{R}+r-\Delta}{\mathrm{R}+r+\Delta} \cdot \frac{\Delta-(\mathrm{R}-r)}{\Delta+\mathrm{R}-r}.$$

Therefore, by computing

$$\tan^2 \tfrac{1}{2}\gamma = \frac{\Delta}{\mathrm{R}+r} \text{ and } \tan^2 \tfrac{1}{2}\nu = \frac{\mathrm{R}-r}{\Delta},$$

we get

$$\tan^2 \tfrac{1}{2}v = \frac{\cos \gamma}{\cos \nu} \text{ and } \tan^2 \tfrac{1}{2}e = \cos \gamma \,.\, \cos \nu,$$

and have also for check or control

$$r \sin v = \mathrm{R} \sin e.$$

If $r > \mathrm{R}$, as in the case of the asteroids, the corresponding formulæ are derived from the foregoing by exchanging v and r with e and R, so that, by computing

$$\tan^2 \tfrac{1}{2}\gamma = \frac{\Delta}{r+\mathrm{R}} \text{ and } \tan^2 \tfrac{1}{2}\nu = \frac{r-\mathrm{R}}{\Delta},$$

we get

$$\tan^2 \tfrac{1}{2}e = \frac{\cos \gamma}{\cos \nu} \text{ and } \tan^2 \tfrac{1}{2}v = \cos \gamma \,.\, \cos \nu.$$

Mercury.

Greenwich Noon. 1894.		v	e	Magnitude. I.	II.
May	29	36°11	10°70	...	−0·95
	30	39·87	11·80	−1·10	−0·90
	31	43·52	12·86	−1·00	−0·85
June	1	47·05	13·88	−0·90	−0·79
	2	50·46	14·86	−0·80	−0·73
	3	53·76	15·80	−0·70	−0·66
	4	56·94	16·70	−0·60	−0·60
	5	60·00	17·56	−0·51	−0·53
	6	62·95	18·37	−0·42	−0·46
	7	65·80	19·14	−0·33	−0·39
	8	68·55	19·87	−0·24	−0·33
	9	71·20	20·55	−0·16	−0·26
	10	73·77	21·19	−0·08	−0·19
	11	76·26	21·79	0·00	−0·13
	12	78·68	22·34	0·07	−0·06
	13	81·03	22·84	0·14	0·00
	14	83·33	23·30	0·21	0·07
	15	85·57	23·71	0·28	0·13
	16	87·77	24·08	0·34	0·20
	17	89·93	24·40	0·40	0·26
	18	92·06	24·67	0·46	0·33
	19	94·17	24·89	0·52	0·39
	20	96·26	25·07	0·58	0·46
	21	98·33	25·19	0·64	0·52
	22	100·40	25·26	0·69	0·59
	23	102·47	25·28	0·75	0·66
	24	104·55	25·24	0·80	0·73
	25	106·65	25·15	0·86	0·81
	26	108·76	25·00	0·91	0·89
	27	110·89	24·79	0·97	0·97
	28	113·05	24·51	1·02	1·06
	29	115·24	24·18	1·08	1·16
	30	117·47	23·78	1·14	1·26
July	1	119·75	23·32	1·20	1·37
	2	122·08	22·79	1·27	1·49
	3	124·46	22·19	1·34	1·62
	4	126·90	21·52	1·41	1·77
	5	129·39	20·77	1·48	1·93
	6	131·96	19·96	1·56	2·10

Greenwich Noon. 1894.		v	e	Magnitude. I.	II.
		°	°		
Aug.	1	132·68	15·93	1·38	1·95
	2	128·74	16 66	1·23	1·65
	3	124·76	17·30	1·08	1·38
	4	120·74	17·84	0·93	1·12
	5	116·67	18·27	0·79	0·89
	6	112·54	18·60	0·64	0·67
	7	108·35	18·83	0 50	0·47
	8	104·10	18·95	0 36	0·29
	9	99·80	18 97	0·22	0·12
	10	95·44	18·89	0·08	−0·04
	11	91·02	18·71	−0·05	−0·19
	12	86·55	18·44	−0·18	−0·32
	13	82·03	18·08	−0·30	−0·44
	14	77·47	17·64	−0·43	−0·55
	15	72 87	17·12	−0·55	−0·65
	16	68·26	16·52	−0·66	−0·74
	17	63·65	15·85	−0 76	−0·81
	18	59·06	15·12	−0·86	−0·87
	19	54·51	14·33	−0·95	−0·92
	20	50·02	13·49	−1·03	−0·96
	21	45·61	12·62	−1·11	−0·99
	22	41·31	11·72	−1·18	−1·00
	23	37·12	10·78	−1·24	−1·01
Nov.	17	130·69	13·73	0·97	1·46
	18	124·06	15·12	0·75	1·02
	19	117·71	16·32	0·55	0·68
	20	111·65	17·33	0·39	0·40
	21	105·89	18·16	0·24	0·18
	22	100·44	18 81	0·11	0·01
	23	95·28	19·32	0·01	−0·12
	24	90·41	19·70	−0·08	−0·22
	25	85·82	19·95	−0·16	−0·30
	26	81·49	20·10	−0·22	−0·36
	27	77·42	20·16	−0·27	−0·40
	28	73·59	20·13	−0·31	−0·42
	29	69·98	20·04	−0·35	−0·44
	30	66·58	19·88	−0·38	−0·45
Dec.	1	63·38	19·67	−0·40	−0·44
	2	60·36	19·42	−0·41	−0·44

Greenwich Noon.	v	e	Magnitude. I.	II.
1894.	°	°		
Dec. 3	57·51	19·12	−0·43	−0·43
4	54·81	18·80	−0·44	−0·41
5	52·26	18·44	−0·45	−0·39
6	49·85	18·06	−0·45	−0·37
7	47·56	17·66	−0·45	−0·35
8	45·39	17·25	−0·46	−0·33
9	43·32	16·82	−0·46	−0·30
10	41·35	16·37	−0·46	−0·28
11	39·46	15·92	−0·46	−0·26
12	37·66	15·45	...	−0·24
13	35·93	14·97	...	−0·21
14	34·27	14·49	...	−0·19
15	32·68	14·01	...	−0·17
1895.				
Jan. 26	31·64	11·27	...	−0·67
27	34·41	11·96	...	−0·70
28	37·33	12·64	...	−0·73
29	40·42	13·31	−0·94	−0·75
30	43·68	13·97	−0·92	−0·78
31	47·13	14·60	−0·90	−0·79
Feb. 1	50·76	15·21	−0·87	−0·80
2	54·58	15·79	−0·84	−0·81
3	58·59	16·33	−0·79	−0·80
4	62·80	16·82	−0·74	−0·78
5	67·21	17·25	−0·68	−0·75
6	71·81	17·61	−0·61	−0·71
7	76·60	17·90	−0·52	−0·64
8	81·57	17·09	−0·42	−0·56
9	86·71	18·17	−0·31	−0·46
10	92·01	18·14	−0·19	−0·33
11	97·44	17·99	−0·05	−0·17
12	103·00	17·70	0·10	0·02
13	108·67	17·26	0·26	0·24
14	114·43	16·66	0·44	0·50
15	120·25	15·91	0·63	0·81
16	126·12	14·99	0·84	1·18
17	132·02	13·91	1·06	1·61
18	137·90	12·68	...	2·11
19	143·73	11·31	...	2·70

Col. Cooper's Observatory,
Markree, Collooney, Ireland.

Ephemeris for Physical Observations of Mars, 1894. By A. Marth.

Greenwich Noon.	Position Angle of ♂'s Axis.	Areographical Longit. of Centre of Disc.	Areographical Latit. of Centre of Disc.	Apparent Diameter.	ϱ	Q	E	Brightness in Star Mag. I.	Brightness in Star Mag. II.
1894.	°	°	°	″	″	°	°		
May 31	341·89	307·68	−23·64	8·82	1·35	246·97	46·05	−0·25	0·25
June 2	341·12	288·01	23·70	8·93	1·37	·87	46·18	−0·28	0·22
4	340·36	268·34	23·74	9·04	1·40	·78	46·30	−0·31	0·20
6	339·62	248·68	23·77	9·15	1·42	·71	46·41	−0·34	0·17
8	338·89	229·02	23·79	9·27	1·45	·65	46·51	−0·37	0·14
10	338·17	209·37	−23·79	9·39	1·47	246·60	46·60	−0·39	0·11
12	337·47	189·73	23·77	9·51	1·49	·57	46·69	−0·42	0·08
14	336·78	170·10	23·74	9·63	1·51	·55	46·77	−0·45	0·06
16	336·11	150·47	23·69	9·76	1·54	·54	46·83	−0·48	0·03
18	345·45	130·86	23·63	9·89	1·56	·54	46·89	−0·51	0·00
20	334·81	111·25	−23·56	10·02	1·59	246·56	46·94	−0·54	−0·03
22	334·19	91·65	23·47	10·15	1·61	·59	46·97	−0·57	−0·06
24	333·59	72·07	23·37	10·28	1·64	·63	47·00	−0·60	−0·09
26	333·00	52·50	23·26	10·42	1·66	·68	47·01	−0·63	−0·12
28	332·43	32·95	23·13	10·56	1·68	·75	47·02	−0·66	−0·15
30	331·83	13·41	−22·99	10·71	1·70	246·83	47·01	−0·69	−0·18
July 2	331·35	353·88	22·85	10·86	1·73	246·92	46·98	−0·72	−0·21
4	330·83	334·37	22·69	11·01	1·75	247·02	46·95	−0·76	−0·25
6	330·33	314·88	22·52	11·16	1·77	247·13	46·90	−0·79	−0·28
8	329·86	295·40	22·34	11·32	1·79	247·25	46·84	−0·82	−0·31
10	329·40	275·94	−22·16	11·48	1·81	247·38	46·76	−0·85	−0·34
12	328·96	256·50	21·96	11·65	1·83	247·52	46·66	−0·88	−0·38
14	328·54	237·09	21·75	11·82	1·85	247·67	46·55	−0·92	−0·41
16	328·14	217·69	21·54	11·99	1·86	247·82	46·42	−0·95	−0·44
18	327·76	198·31	21·33	12·16	1·88	247·99	46·28	−0·98	−0·48
20	327·40	178·96	−21·11	12·34	1·89	248·17	46·12	−1·02	−0·51
22	327·05	159·63	20·88	12·53	1·91	248·35	45·94	−1·05	−0·55
24	326·73	140·32	20·64	12·72	1·92	248·54	45·74	−1·08	−0·58
26	326·42	121·04	20·41	12·91	1·93	248·74	45·52	−1·12	−0·62
28	326·13	101·78	20·17	13·11	1·94	248·94	45·28	−1·15	−0·66
30	325·86	82·55	−19·93	13·31	1·95	249·15	45·01	−1·19	−0·69
Aug. 1	325·60	63·35	19·69	13·52	1·96	249·37	44·72	−1·23	−0·73
3	325·36	44·18	19·45	13·73	1·96	249·59	44·41	−1·26	−0·77
5	325·14	25·04	19·21	13·95	1·96	249·81	44·07	−1·30	−0·81

Greenwich Noon.	Position Angle of ♂'s Axis.	Areographical Longit. of Centre of Disc.	Areographical Latit. of Centre of Disc.	Apparent Diameter.	q	Q	E	Brightness in Star Mag. I.	Brightness in Star Mag. II.
1894.	°	°	°	″	″	°	°		
Aug. 7	324·93	5·93	18·98	14·17	1·96	250·04	43·70	−1·33	−0·85
9	324·74	346·85	−18·75	14·40	1·96	250·27	43·30	−1·37	−0·89
11	324·57	327·81	18·52	14·63	1·95	250·51	42·87	−1·41	−0·93
13	324·41	308·80	18·30	14·87	1·95	250·75	42·42	−1·45	−0·97
15	324·26	289·82	18·08	15·11	1·94	250·99	41·93	−1·48	−1·01
17	324·12	270·88	17·87	15·36	1·92	251·23	41·41	−1·52	−1·05
19	324·00	251·98	−17·66	15·61	1·90	251·47	40·85	−1·56	−1·09
21	323·89	233·12	17·47	15·87	1·88	251·71	40·26	−1·60	−1·14
23	·79	214·30	17·29	16·13	1·85	251·95	39·63	−1·64	−1·18
25	·70	195·52	17·12	16·40	1·82	252·19	38·96	−1·68	−1·23
27	·62	176·78	16·96	16·67	1·79	252·43	38·25	−1·72	−1·27
29	323·55	158·09	−16·81	16·95	1·75	252·67	37·49	−1·76	−1·32
31	·49	139·45	16·68	17·23	1·71	252·91	36·68	−1·79	−1·36
Sept. 2	·44	120·86	16·57	17·51	1·66	253·15	35·83	−1·83	−1·41
4	·39	102·32	16·47	17·79	1·60	253·38	34·93	−1·87	−1·46
6	·35	83·83	16·40	18·08	1·54	253·61	33·98	−1·91	−1·50
8	323·32	65·38	−16·34	18·37	1·48	253·84	32·98	−1·95	−1·55
10	·30	46·99	16·30	18·65	1·41	254·08	31·93	−1·99	−1·60
12	·28	28·65	16·28	18·93	1·34	254·31	30·83	−2·02	−1·64
14	·27	10·37	16·28	19·21	1·26	254·54	29·67	−2·06	−1·69
16	·26	352·15	16·30	19·48	1·18	254·78	28·45	−2·09	−1·74
18	323·26	333·98	−16·35	19·75	1·09	255·02	27·18	−2·13	−1·78
20	·27	315·86	16·42	20·01	1·00	255·27	25·85	−2·16	−1·83
22	·28	297·80	16·51	20·26	0·91	258·54	24·47	−2·19	−1·87
24	·30	279·80	16·63	20·50	0·82	255·83	23·03	−2·22	−1·92
26	·32	261·86	16·77	20·72	0·72	256·14	21·53	−2·24	−1·96
28	323·36	243·97	−16·93	20·93	0·63	256·50	19·98	−2·27	−2·00
30	·40	226·13	17·11	21·12	0·54	256·91	18·38	−2·29	−2·04
Oct. 2	·45	208·33	17·31	21·28	0·45	257·40	16·74	−2·31	−2·08
4	·51	190·58	17·53	21·42	0·37	258·00	15·05	−2·32	−2·12
6	·57	172·88	17·76	21·53	0·29	258·74	13·33	−2·34	−2·15
8	323·64	155·21	−18·01	21·62	0·22	259·73	11·58	−2·35	−2·18
10	323·72	137·57	18·28	21·67	0·16	261·10	9·80	−2·35	−2·21
12	323·81	119·95	18·55	21·70	0·11	263·10	8·00	−2·35	−2·23
14	323·91	102·36	18·83	21·69	0·06	266·3	6·21	−2·35	−2·26
16	324·02	84·78	19·12	21·65	0·03	272·1	4·44	−2·35	−2·28
18	324·13	67·20	−19·41	21·58	0·013	285·3	2·78	−2·34	−2·30

	Greenwich Noon.	Position Angle of ♂'s Axis.	Areographical Longit. of Centre of Disc.	Areographical Latit. of Centre of Disc.	Apparent Diameter.	ϕ	Q	E	Brightness in Star Mag. I.	Brightness in Star Mag. II.
	1894.	°	°	°	″	″	°	°		
Oct.	20	324·24	49·63	−19·70	21·47	0·004	324·8	1·60	−2·32	−2·30
	22	324·36	32·05	19·99	21·33	0·009	23·8	2·05	−2·31	−2·28
	24	324·48	14·46	20·28	21·16	0·02	46·3	3·54	−2·29	−2·23
	26	324·61	356·85	20·56	20·97	0·04	54·8	5·23	−2·26	−2·19
	28	324·73	339·21	−20·83	20·74	0·08	59·02	6·94	−2·23	−2·14
	30	324·85	321·54	21·10	20·49	0·12	61·50	8·65	−2·20	−2·08
Nov.	1	324·96	303·84	21·36	20·22	0·16	63·12	10·33	−2·17	−2·02
	3	325·06	286·09	21·60	19·92	0·22	64·24	11·97	−2·13	−1·96
	5	325·16	268·30	21·83	19·61	0·27	65·07	13·61	−2·09	−1·90
	7	325·25	250·46	−22·04	19·29	0·33	65·68	15·11	−2·04	−1·84
	9	325·33	232·56	22·24	18·95	0·39	66·17	16·60	−2·00	−1·77
	11	325·39	214·61	22·42	18·60	0·46	66·55	18·04	−1·95	−1·71
	13	325·44	196·60	22·59	18·25	0·52	66·86	19·42	−1·90	−1·64
	15	325·48	178·54	22·75	17·89	0·58	67·12	20·75	−1·85	−1·58
	17	325·50	160·42	−22·89	17·53	0·64	67·34	22·02	−1·80	−1·51
	19	325·51	142·25	23·01	17·16	0·70	67·52	23·23	−1·74	−1·44
	21	325·50	124·02	23·11	16·80	0·75	67·68	24·39	−1·69	−1·37
	23	325·48	105·73	23·20	16·44	0·80	67·82	25·49	−1·63	−1·31
	25	325·44	87·38	23·28	16·08	0·85	67·94	26·53	−1·57	−1·24
	27	325·39	68·98	−23·34	15·72	0·89	68·05	27·52	−1·52	−1·17
	29	325·33	50·53	23·39	15·37	0·93	68·15	28·45	−1·46	−1·11
Dec.	1	325·25	32·03	23·42	15·03	0·96	68·25	29·33	−1·40	−1·04
	3	325·17	13·47	23·43	14·69	0·99	68·34	30·16	−1·35	−0·97
	5	325·07	354·87	23·43	14·36	1·02	68·43	30·94	−1·29	−0·91
	7	324·96	336·22	−23·42	14·04	1·05	68·52	31·17	−1·23	−0·84
	9	324·84	317·52	23·39	13·72	1·07	68·61	32·36	−1·17	−0·78
	11	324·71	298·79	23·35	13·42	1·09	68·69	33·01	−1·12	−0·72
	13	324·58	280·02	23·30	13·12	1·10	68·78	33·61	−1·06	−0·66
	15	324·44	261·21	23·23	12·83	1·11	68·87	34·17	−1·01	−0·60
	17	324·29	242·36	−23·15	12·54	1·12	68·96	34·70	−0·95	−0·54
	19	324·14	223·48	23·05	12·27	1·12	69·05	35·19	−0·90	−0·48
	21	323·99	204·56	22·94	12·00	1·12	69·15	35·64	−0·84	−0·42
	23	323·84	185·62	22·82	11·75	1·12	69·25	36·06	−0·79	−0·36
	25	323·68	166·65	22·69	11·50	1·12	69·36	36·44	−0·74	−0·31
	27	323·53	147·65	−22·54	11·25	1·12	69·48	36·79	−0·68	−0·25
	29	323·38	128·63	22·38	11·02	1·12	69·60	37·12	−0·63	−0·20
	31	323·23	109·58	22·21	10·79	1·11	69·73	37·41	−0·58	−0·14

Greenwich Noon.		Position Angle of ♂'s Axis.	Areographical Longit. of Centre of Disc.	Areographical Latit. of Centre of Disc.	Apparent Diameter.	q	Q	E	Brightness in Star Mag. I.	Brightness in Star Mag. II.
1895.		°	°	°	″	″	°	°		
Jan.	2	323·08	90·51	−22·03	10·57	1·10	69·86	37·68	−0·53	−0·09
	4	322·94	71·42	21·83	10 36	1·09	69·99	37·93	−0·48	−0·04
	6	322·80	52·31	−21·62	10·15	1·08	70·14	38·15	−0·43	0·01
	8	322·67	33·18	21·40	9·95	1·07	70·30	38·34	−0·38	0·06
	10	322·54	14·03	21·17	9·75	1·06	70·46	38·51	−0·34	0·11
	12	322·42	354·87	20·93	9·57	1·05	70·63	38·66	−0·29	0·16
	14	322·31	335·70	20·67	9·39	1·03	70·80	38 79	−0·24	0·21
	16	322·21	316·51	−20·41	9·21	1·02	70·99	38·90	−0·20	0·25
	18	322·12	297·31	20 13	9·04	1·01	71·18	38·99	−0·15	0 30
	20	322·04	278·10	19·84	8 87	0·99	71·38	39·06	−0·11	0·34
	22	321·97	258·88	19·55	8·71	0·98	71·59	39·12	−0·07	0·39
	24	321·91	239·65	19 24	8·56	0·96	71·81	39·16	−0·02	0·43
	26	321·86	220·41	−18·92	8·41	0·95	72·04	39·18	0 02	0·47
	28	321·83	201·16	18·59	8·26	0·93	72·28	39·19	0·06	0·51
	30	321·81	181·91	18·25	8·12	0·91	72·52	39·18	0·10	0·55
Feb.	1	321·80	162·65	17·90	7·99	0·90	72·78	39 16	0·14	0·59
	3	321·80	143·38	17·55	7·86	0·88	73·04	39·13	0·18	0·63
	5	321·82	124 11	−17·18	7·73	0·86	73·31	39·08	0·22	0 67
	7	321·86	104·83	16·80	7·60	0·85	73·59	39·02	0·26	0·71
	9	321·91	85·55	16·42	7·48	0·83	73·88	38·95	0·29	0·74
	11	321·97	66·26	16·03	7·37	0·82	74·18	38·87	0·33	0·78
	13	322·05	46·97	15·63	7·25	0·80	74·49	38·78	0·37	0·82
	15	322·14	27·68	−15·22	7·14	0·78	74·81	38·67	0·40	0·85

1894 April 7·3. Autumn equinox of ♂'s northern hemisphere.
1894 August 31·3. Winter solstice „ „ „
1895 February 7·3. Spring equinox „ „ „

Q denotes the position angle, and q the amount of the greatest defect of illumination, E (as in preceding ephemerides) the phase-angle or the areocentric angle between Earth and Sun.

The last column gives the brightness of *Mars* expressed in star magnitudes, the brightness at mean opposition being assumed to be $-1^{m}\cdot787$, according to Prof. G. Müller's determination (in vol. viii. of the *Publicationen des Astrophysikalischen Observatoriums zu Potsdam*), and the diminution of brightness due to the phase being computed on two suppositions—(I) that it depends simply on the proportion of the unilluminated portion to the whole of the disc, so that the alteration of magnitude amounts to $+5$ log sec $\frac{1}{2}$ E; or (II) that the alteration is repre-

sented by Müller's empirical formula $+0^{\circ}.01426\,a$, in which the phase angle a (here E) is expressed in degrees.

The data of the ephemeris are to be interpolated directly for the times for which they are required, since the equation of light has already been taken into account. The differences between successive values of the areographical longitudes of the centre vary from $700^{\circ}.33$ to $702^{\circ}.43$.

The adopted zero meridian will pass the centre of the disc at the following Greenwich mean times:—

1894.	h	m	1894.	h	m	1894.	h	m
May 31	3	35·2	July 2	0	25·1	Aug. 2	20	58·4
June 1	4	15·6	3	1	5·3	3	21	37·8
2	4	56·1	4	1	45·4	4	22	17·1
3	5	36·5	5	2	25·4	5	22	56·4
4	6	16·9	6	3	5·5	6	23	25·6
5	6	57·4	7	3	45·6	8	0	14·8
6	7	37·8	8	4	25·6	9	0	54·0
7	8	18·2	9	5	5·6	10	1	33·2
8	8	58·6	10	5	45·6	11	2	12·3
9	9	39·0	11	6	25·5	12	2	51·3
10	10	19·4	12	7	5·5	13	3	30·3
11	10	59·8	13	7	45·4	14	4	9·3
12	11	40·2	14	8	25·3	15	4	48·3
13	12	20 5	15	9	5·1	16	5	27·2
14	13	0·9	16	9	45·0	17	6	6·1
15	13	41·2	17	10	24·8	18	6	44·9
16	14	21·6	18	11	4·6	19	7	13·7
17	15	1·9	19	11	44·4	20	8	2·5
18	15	42·2	20	12	24·1	21	8	41·2
19	16	22·5	21	13	3·9	22	9	19·8
20	17	2·9	22	13	43·6	23	9	58·4
21	17	43·1	23	14	23·3	24	10	37·0
22	18	23·4	24	15	2·9	25	11	15·5
23	19	3·7	25	15	42·5	26	11	54·0
24	19	43·9	26	16	22·1	27	12	32·4
25	20	24·1	27	17	1·7	28	13	10·8
26	21	4·3	28	17	41·2	29	13	49·1
27	21	44·5	29	18	20·7	30	14	27·4
28	22	24·7	30	19	0·2	31	15	5·6
29	23	4·9	31	19	39·7	Sept. 1	15	43·8
30	23	45·0	Aug. 1	20	19·1	2	16	21·9

1894.	h	m
Sept. 3	16	59·9
4	17	37·9
5	18	15·9
6	18	53·8
7	19	31·6
8	20	9·4
9	20	47·1
10	21	24·8
11	22	2·4
12	22	39·9
13	23	17·4
14	23	54·8
16	0	32·2
17	1	9·5
18	1	46·8
19	2	24·0
20	3	1·1
21	3	38·2
22	4	15·2
23	4	52·1
24	5	29·0
25	6	5·8
26	6	42·6
27	7	19·3
28	7	55·9
29	8	32·5
30	9	9·1
Oct. 1	9	45·6
2	10	22·0
3	10	58·4
4	11	34·8
5	12	11·1
6	12	47·3
7	13	23·8
8	13	59·7
9	14	35·9
10	15	12·0
11	15	48·1
12	16	24·2

1894.	h	m
Oct. 13	17	0·3
14	17	36·4
15	18	12·4
16	18	48·4
17	19	24·5
18	20	0·5
19	20	36·5
20	21	12·5
21	21	48·6
22	22	24·6
23	23	0·7
24	23	36·8
26	0	12·9
27	0	49·1
28	1	25·3
29	2	1·5
30	2	37·7
31	3	14·0
Nov. 1	3	50·3
2	4	26·7
3	5	3·1
4	5	39·6
5	6	16·1
6	6	52·7
7	7	29·3
8	8	6·0
9	8	42·8
10	9	19·6
11	9	46·5
12	10	33·4
13	11	10·4
14	11	47·4
15	12	24·5
16	13	1·7
17	13	38·9
18	14	16·2
19	14	53·6
20	15	31·0
21	16	8·5

1894.	h	m
Nov. 22	16	46·0
23	17	23·6
24	18	1·3
25	18	39·0
26	19	16·8
27	19	54·7
28	20	32·6
29	21	10·5
30	21	48·5
Dec. 1	22	26·6
2	23	4·7
3	23	42·9
5	0	21·1
6	0	59·3
7	1	37·6
8	2	16·0
9	2	54·4
10	3	32·9
11	4	11·4
12	4	49·9
13	5	28·5
14	6	7·1
15	6	45·8
16	7	24·5
17	8	3·2
18	8	42·0
19	9	20·8
20	9	59·7
21	10	38·6
22	11	17·5
23	11	56·4
24	12	35·4
25	13	14·4
26	13	53·4
27	14	32·4
28	15	11·5
29	15	50·6
30	16	29·7
31	17	8·9

1895.	h	m	1895.	h	m	1895.	h	m
Jan. 1	17	48·1	Jan. 17	3	38·2	Feb. 1	13	31·1
2	18	27·3	18	4	17·6	2	14	10·7
3	19	6·5	19	4	57·1	3	14	50·3
4	19	45·8	20	5	36·6	4	15	29·9
5	20	25·1	21	6	16·1	5	16	9·5
6	21	4·4	22	6	55·6	6	16	49·1
7	21	43·7	23	7	35·1	7	17	28·8
8	22	23·0	24	8	14·6	8	18	8·4
9	23	2·3	25	8	54·1	9	18	48·0
10	23	41·7	26	9	33·7	10	19	27·7
12	0	21·1	27	10	13·2	11	20	7·3
13	1	0·5	28	10	52·8	12	20	46·9
14	1	39·9	29	11	32·4	13	21	26·6
15	2	19·3	30	12	11·9	14	22	6·2
16	2	58·7	31	12	51·5			

The present ephemeris is founded upon the same elements as those for the preceding oppositions, as this year's observations will probably yield such effective contributions towards a closer determination of the position of the planet's axis, and of the leading points of areography, that it would be premature to make any alterations till the results of the observations are known. In this respect it is specially desirable to get good places of Schiaparelli's *Sinus Titanum*, since those obtained in 1879 are not sufficiently accordant, and also good places of the *Fastigium Aryn* and of the region near. The *Sinus Titanum* will pass the central meridian near the centre of the disc, about 11^h 6 after the passage of the zero meridian.

As Schröter's sketches Nos. 25 and 26* were made just a hundred years ago, in 1794, the present occasion seems not unsuitable for pointing out, in fairness to them, that they represent, however imperfectly, the region of the Kaiser Sea or Syrtis, or Mer de Sablier. The reason why there has been any difficulty in their interpretation is to be found in a simple slip in writing or mistake in reading. The two sketches were made in the month of May, not März, or March, 1794. This is indicated already by the aspect of the unilluminated portions of the discs, which are shown to be on the following (not the preceding) side, and somewhat less than in the next sketch, dated June 1. Moreover, Schröter expressly states that the time of No. 25 was $30\frac{1}{2}$ days after the opposition, which occurred on the morning of April 24, so that *after* gives the evening of May 24, while *before* would give the printed date. But at the given hour of March 24 *Mars* was not yet above the horizon.

* J. H. Schröter, *Areographische Beiträge*, herausgegeben von Van de Sande Bakhuyzen, 1881, and also C. Flammarion, *La Planète Mars*, 1892, p. 72.

Errata.

In Mr. Innes' paper, ***Monthly Notices***, vol. liv.

Page 292, line 5 from bottom,

for 9·553121 *read* 9·5531214.

Page 295, bottom line,

for 9·4553008 *read* 9·4543008.

CONTENTS.

	PAGE
Fellows elected	343
Candidates proposed	*ib.*
Presents announced	344
David Gill, Remarks on the Best Method of Determining the Positions of the Planets by Observation	*ib.*
W. E. Cooke, Note on Star Corrections in N.P.D.	358
Professor H. H. Turner, On Star Corrections	359
Captain W. de W. Abney, Graduating Wedges	368
Isaac Roberts, Photograph of the Cluster M. 46, and of the Nebula H IV. 39 *Argûs*	370
Isaac Roberts, Photograph of a "New" Spiral Nebula in *Perseus*	371
Isaac Roberts, Photograph of the Nebula H I. 156 *Persei*	*ib.*
H. F. Newall, Notes on some Photographs taken with a Visual Telescope	373
H. C. Russell, The Star Cluster 3315 (Cape Observations)	380
H. C. Russell, A Seconds Contact-Maker for Astronomical Clocks	381
Professor A. A. Rambaut, Occultation of *a Virginis* observed at Dunsink 1894 March 22	383
Royal Observatory, Greenwich, Observations of Denning's Comet (*a* 1894)	384
W. E. Plummer, Observations of Comet *a* 1894 (Denning)	386
A. Marth, Note on the Computation of the Brightness of the Planets, with some Ephemerides for Observations of the Brightness of *Mercury*	388
A. Marth, Ephemeris for Physical Observations of *Mars*, 1894	394
Errata	401

Printed by SPOTTISWOODE & Co., New-street Square, London; and Published at the Apartments of the Society, May 1894.

UNIVERSITY OF LONDON
- 6 NOV 1952
LIBRARY